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THE CELLULAR BASIS OF HEREDITY AND DEVELOPMENT[1]

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A. Introductory

HEREDITY is to-day the central problem of biology. This problem may be approached from many sides—that of the observer, the statistician, the practical breeder, the experimenter, the embryologist, the cytologist—but these different aspects of the subject may be reduced to three general methods of study, (1) the observational and statistical, (2) the experimental, (3) the cytological and embryological. Before taking up these different aspects of heredity it is important that we should have clear definitions of the terms employed and a fairly accurate conception of the processes involved.

1. *Definitions*

Heredity originally meant heirship, or the transmission of property from parents to children, and in the field of biology it has been defined erroneously as "the transmission of qualities or characteristics, mental or physical, from parents to offspring" (Century Dictionary). The colloquial meaning of the word has led to much confusion in biology, for it carries with it the idea of the transmission from one generation to the next of ownership in property. A son may inherit a house from his father and a farm from his mother, the house and farm remaining the same though the ownership has passed from parents to son. And when it is said that a son inherits his stature from his father and his complexion from his mother, the stature and complexion are usually thought of only in their developed condition, while the great fact of development is temporarily forgotten. Of course there are no "qualities" or "characteristics" which are "transmitted" as such from one generation to the next. Such terms are not without fault when used

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merely as figures of speech, but when interpreted literally, as they frequently are, they are altogether misleading; they are the result of reasoning about names rather than facts, of getting far from phenomena and philosophizing about them. The comparison of heredity to the transmission of property from parents to children has produced confusion in the scientific as well as in the popular mind. It is only necessary to recall the most elementary facts about development to recognize that in a literal sense parental characteristics are never transmitted to children.

2. *The Transmission Hypothesis*

And yet the idea that the characteristics of adult persons are transmitted from one generation to the next is a very ancient one and was universally held until the most recent times. Before the details of development were known it was natural to suppose, as Hippocrates did, that white-flowered plants gave rise to white-flowered seeds and that blue-eyed parents produced blue-eyed germs, without attempting to define what was meant by white-flowered seed or blue-eyed germs. And even after the facts of development were fairly well known it was generally held that the germ cells were produced by the adult animal or plant and that the characteristics of the adult were in some way carried over to the germ cells; but the manner in which this supposed transmission took place remained undefined until Darwin attempted to explain it by his "provisional hypothesis of pangenesis." Darwin assumed that minute particles or "gemmules" were given off by every cell of the body, at every stage of development, and that these gemmules then collected in the germ cells which thus became storehouses of little germs from all parts of the body. Afterwards, in the development of these germ cells, the gemmules, or little germs, developed into cells and organs similar to those from which they came.

3. *Germinal Continuity and Somatic Discontinuity*

Many ingenious hypotheses have been devised to explain things which are not true, and this is one of them. The doctrine that adult organisms manufacture germ cells and transmit their characters to them is known to be erroneous. Neither germ cells nor any other kind of cells are formed by the body as a whole, but every cell in the body comes from a preceding cell by a process of division, and germ cells are formed, not by contributions from all parts of the body, but by division of preceding cells which are derived ultimately from the fertilized egg (Fig. 23). The hen does not produce the egg, but the egg produces the hen and also other eggs. Individual traits are not transmitted from the hen to the egg, but they develop out of germinal factors which are carried along from cell to cell, and thus from generation to generation.

There is a continuity of germinal substance, and usually of germinal cells, from one generation to the next. In some animals the germ cells are set apart at a very early stage of development, sometimes in

the early cleavage stages of the egg. In other cases the germ cells are first recognizable at later stages, but in practically every case they arise from germinal or embryonic cells which have not differentiated into somatic tissues. Germinal continuity and somatic discontinuity of successive generations in sexually produced organisms is not a theory but an established fact. In general, germ cells do not come from differentiated somatic cells, but only from undifferentiated germinal cells, and if in a few cases differentiated cells may reverse the process of development and become embryonic cells and even germ cells it does not destroy this principle of germinal continuity and somatic discontinuity.

Thus the problem which faces the student of heredity and development has been cut in two; he no longer inquires how the body produces the germ cells, for this does not happen, but merely how the latter produce the body and other germ cells. The germ is the undeveloped organism which forms the bond between successive generations; the person is the developed organism which arises from the germ under the influence of environmental conditions. The person develops and dies in each generation; the germ plasm is the continuous stream of living substance which connects all generations. The person nourishes and protects the germ, and in this sense the person is merely the carrier of the germ plasm, the mortal trustee of an immortal substance.

This contrast of the germ and the person, of the undeveloped and the developed organism, is fundamental in all modern work on heredity. It was especially emphasized by Weismann in his germ plasm theory and recently it has been given prominence by Johannsen under the terms genotype and phenotype; the genotype is the fundamental hereditary constitution of an organism—it is the germinal type; the phenotype is the developed organism with all of its visible characters—it is the somatic type.

But important as this distinction is between germ and soma it has sometimes been over-emphasized. This is one of the chief faults of Weismann's theory. The germ and the soma are generically alike, but specifically different. Both germ cells and somatic cells have come from the same oosperm, but have differentiated in different ways; the tissue cells have lost certain things which the germ cells retain and have developed other things which remain undeveloped in the germ cells. But the germ cells do not remain undifferentiated; both egg and sperm are differentiated, the former for receiving the sperm and for the nourishment of the embryo, the latter for locomotion and for penetration into the egg. But while the differentiations of tissue cells are usually irreversible, so that they do not again become germinal cells, the differentiations of the sex cells are reversible, so that these cells, after their union, again become germinal cells.

In many theories of heredity it is assumed that there is a specific "inheritance material," distinct from the general protoplasm whose function is the "transmission" of hereditary properties from generation

to generation, and whose characteristics, as compared with the general protoplasm, are great stability, independence and continuity. This is the idioplasm of Nägeli, the germ-plasm of Weismann. But there is no reason to suppose that "germ-plasm" is anything other than germinal protoplasm, which is found in all cells in early stages of development but which becomes limited in quantity or altered in quality in tissue cells. A "germ-plasm" which is absolutely distinct from and independent of the general protoplasm is a mere fiction which finds no justification in reality.

4. *The Units of Living Matter*

The entire cell, nucleus and cytoplasm, is the ultimate unit of living matter which is capable of independent existence. Neither the nucleus nor the cytoplasm can for long live independently of each other, but the entire cell can perform all the fundamental vital processes. It transforms food into its own living material, it grows and divides, it is capable of responding to many kinds of stimuli. But while the parts of a cell are not capable of independent existence they may perform certain of these vital processes.

Not only is the cell as a whole capable of assimilation, growth and division, but every living part of the cell has this power. The nucleus builds foreign substances into its own substance, and after it has grown to a certain size it divides into two; the cytoplasm does the same, and this process of assimilation, growth and division occurs in many parts of the nucleus and cytoplasm, such as the chromosomes, chromomeres, centrosomes, plastosomes, etc. In all cases cells come from cells, nuclei from nuclei, chromosomes from chromosomes, centrosomes from centrosomes, and probably plastosomes from plastosomes, etc.

Indeed, the manner in which all living matter grows indicates that every minute particle of protoplasm has this power of taking in food substance and of dividing into two particles when it has grown to maximum size. Presumably this power of assimilation, growth and division is possessed by particles of protoplasm which are invisible with the highest powers of our microscopes, though it is probable that these particles are much larger than the largest molecules known to chemistry. The smallest particle which can be seen with the most powerful microscope in ordinary light is about 250 $\mu\mu$ (millionths of a millimeter) in diameter. The largest molecules are probably about 10 $\mu\mu$ in diameter. Between these invisible molecules and the just visible particles of protoplasm there may be other units of organization. These hypothetical particles of protoplasm have been supposed by many authors to be the ultimate units of assimilation, growth and division. In so far as these units are supposed to be different in different species, or with respect to different hereditary characters, they are known also as inheritance units.

It is assumed in practically all theories of heredity that the "inher-

itance material," or more correctly the germinal protoplasm, is composed of ultra-microscopical units which have the power of individual growth and division and which are capable of undergoing many combinations and dissociations during the course of development, by which combinations and dissociations they are transformed into the structures of the adult. Various names have been given to such units by different authors; they are the *physiological units* of Herbert Spencer, the *gemmules* of Darwin, the *plastidules* of Elsberg and Haeckel, the *pangenes* of de Vries, the *plasomes* of Wiesner, the *idioblasts* of Hertwig, the *biophores* and *determinants* of Weismann.

With the publication of Weismann's work on the germ-plasm in 1892 speculation with regard to these ultra-microscopic units of life and of heredity reached a climax and began to decline, owing to the highly speculative character of the evidence as to the existence, nature and activities of such units. But with the rediscovery of Mendel's principles of heredity the necessity of assuming the existence of inheritance units of some kind once more became evident, and, without attempting to define what such units are or how they behave modern students of heredity invariably accept their existence. They are now called *determiners* or *factors* or *genes,* and are usually thought of as elements or units of the germ cells which condition the characters of the developed organism, and which are in a measure independent of one another; though of course neither they nor any other parts of a cell are really independent in the sense that they can exist apart from one another. They are to be thought of as we think of certain chemical radicals which exist only in combination with other chemical elements in the form of molecules, and yet may preserve their identity in many different combinations.

If there are inheritance units, such as determiners or genes, as practically all students of heredity maintain, they must be contained in the germ cells, and it becomes one of the fundamental problems of biology to find out where and what these units are. But whether we assume the existence of these units or not we know that the germ cells are exceedingly complex, that they contain many visible units such as chromosomes, chromomeres, plastosomes and microsomes, and that with every great improvement in the microscope and in microscopical technique other structures are made visible which were invisible before, and whether the particular hypothetical units just named are present or not seems to be a matter of no great importance, seeing that, so far as the analysis of the microscope is able to go, there are in all protoplasm differentiated units which are combined into a system—in short, there is organization.

5. *Heredity and Development*

The germ cells are individual entities and after the fertilization of the egg the new individual thus formed remains distinct from every other individual. Furthermore, from its earliest to its latest stage of

development it is one and the same organism; the egg is not one being and the embryo another and the adult a third, but the egg of a human being is a human being in the one-celled stage of development, and the characteristics of the adult develop out of the egg and are not in some mysterious way grafted upon it or transmitted to it.

Parents do not transmit their characters, but their germ cells, to their offspring, which germ cells in the course of long development give rise to adult characters similar to those of the parents. The thing which persists more or less completely from generation to generation is the organization of the germ cells which differentiate in similar ways in successive generations if the extrinsic factors of development remain similar.

In short, *heredity may be defined as the particular germinal organization which is transmitted from one generation to the next: inheritance or heritage is the sum of all those qualities which are determined or caused by this germinal organization. Development is progressive and coordinated differentiation of this germinal organization, by which it is transformed into the adult organization. Differentiation is the formation and localization of many different kinds of substances out of the germinal substances, of many different structures and functions out of the relatively simple structures and functions of the oosperm.*

This germinal organization influences not merely adult characters, but also the character of every stage from the egg to the adult condition. For every inherited character, whether embryonic or adult, there is some germinal basis. We receive from our parents germ cells of a particular kind and constitution and under given conditions of environment these cells undergo regular transformations and differentiations in the course of development which differentiations lead to particular adult characteristics. In the last analysis the causes of heredity and development are problems of cell structures and functions—problems of the formation of particular kinds of germ cells, of the fusion of these cells in fertilization, and of the subsequent formation of the various types of somatic cells from the fertilized egg cell.

B. The Germ Cells

Observations and experiments on developed animals and plants have furnished us with a knowledge of the finished products of inheritance, but the actual stages and causes of inheritance, the real mechanisms of heredity, are to be found only in a study of the germ cells and of their development. Although many phenomena of inheritance have been discovered in the absence of any definite knowledge of the mechanism of heredity, a scientific explanation of these phenomena must wait upon the knowledge of their causes. In the absence of such knowledge it has been necessary to formulate theories of heredity to account for the facts, but these theories are only temporary scaffolding to bridge the gaps in our knowledge, and if we knew all that could be known about

the germ cells and their development we should have little need of theories. In the first lecture we looked at the germ cells and their development from the outside, as it were; let us now look inside these cells and study their minuter structures and functions.

Only a beginning has been made in this minute study of the germ cells and of their transformation into the developed animal, and it seems probable that it may engage the attention of many future

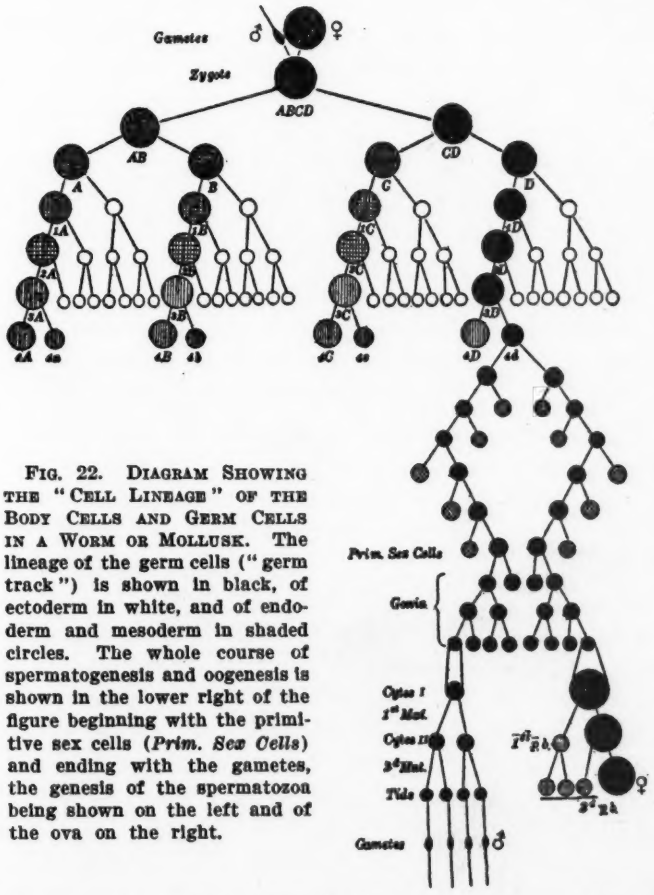

FIG. 22. DIAGRAM SHOWING THE "CELL LINEAGE" OF THE BODY CELLS AND GERM CELLS IN A WORM OR MOLLUSK. The lineage of the germ cells ("germ track") is shown in black, of ectoderm in white, and of endoderm and mesoderm in shaded circles. The whole course of spermatogenesis and oogenesis is shown in the lower right of the figure beginning with the primitive sex cells (*Prim. Sex Cells*) and ending with the gametes, the genesis of the spermatozoa being shown on the left and of the ova on the right.

generations of biologists, but nevertheless we have come far since that day, only about thirty-five years ago, when Oscar Hertwig first saw the approach and union of the egg and sperm nuclei within the fertilized egg. Indeed so rapid has been the advance of knowledge in this field that many of the pioneers in this work are still active in research.

1. *Fertilization*

The development of the individual may be said to begin with the fertilization of the egg, though it is evident that both egg and sperm must have had a more remote beginning, and that they also have undergone a process of development by which their peculiar characteristics of

structure and function have arisen—a subject to which we shall return later. But the developmental processes which lead to the formation of fully developed ova and spermatozoa come to a full stop before fertilization and they do not usually begin again until a spermatozoon has entered an ovum, or until the latter has been stimulated by some other outside means. In some animals and plants eggs may develop regularly without fertilization, the stimulus to development being supplied by

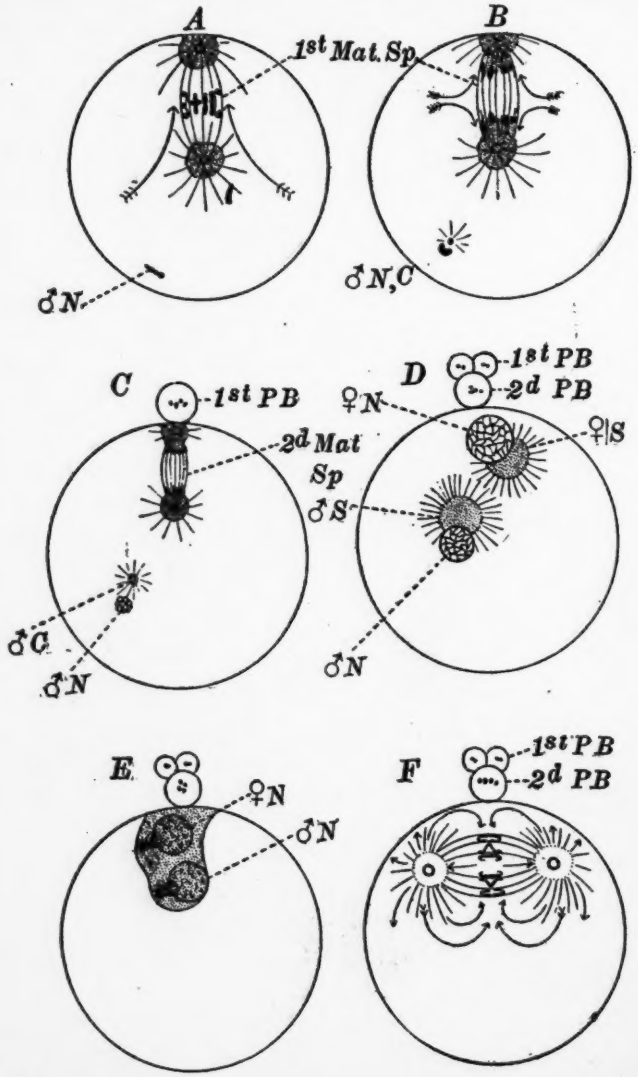

FIG. 23. DIAGRAMS OF THE MATURATION AND FERTILIZATION OF THE EGG OF A MOLLUSK (*Crepidula*). *A, B.* First maturation division (*1st Mat. Sp.*) *C.* Second maturation division (*2d Mat. Sp.*) and first polar body (*1st PB*) resulting from first division. ♂*N*, sperm nucleus, ♂*C*, sperm centrosome. *D.* Approach of sperm nucleus (♂*N*) and sperm (♂*S*) to egg nucleus (♀*N*) and sphere (♀*S*); the second polar body (*2dPB*) has been formed and the forest has divided (*1st PB*). *E.* Meeting of egg and sperm nuclei and origin of cleavage centrosomes. *F.* First cleavage of egg showing direction of currents in the cell.

certain external or internal conditions; in other cases, as Loeb discovered, eggs which would never develop if left to themselves may be experimentally stimulated by physical or chemical changes in the environment, so that they undergo regular development. The development of an egg without previous fertilization is known as *parthenogenesis* or virgin reproduction; if it occurs in nature it is natural parthenogenesis, if in experiments it is artificial parthenogenesis. Natural parthenogenesis is relatively rare and in the vast majority of animals and plants the egg does not begin to develop until a spermatozoon has entered it.

But the spermatozoon not only stimulates the egg to develop, as environmental conditions may also do, but it carries into the egg living substances which are of great significance in heredity. Usually only the head of the spermatozoon enters the egg (Figs. 4–7) and this consists almost entirely of nuclear material which has a strong chemical affinity for certain dyes, and hence is called *chromatin* (Figs. 23 *A* and *B*); when the egg has matured and is ready to be fertilized its nucleus also consists of a small mass of chromatin (Fig. 23 *C*). Both of these condensed chromatic nuclei then grow in size and become less chromatic by absorbing from the egg a substance which is not easily stained by dyes and hence is called *achromatin* (Fig. 23 *D* and *E*). The chromatin then becomes scattered through each nucleus in the form of granules or threads which are embedded in the achromatin; this is the condition of a typical "resting" nucleus. The spermatozoon also brings into the egg a *centrosome,* or division center, around which an *aster* appears consisting of radiating lines in the protoplasm of the egg (Fig 23 *B*).

The moment that the spermatozoon touches the surface of the egg the latter throws out at the point touched a prominence, or reception cone (Fig. 4), and as soon as the head of the sperm has entered this cone some of the superficial protoplasm of the egg flows to this point and then turns into the interior of the egg in a kind of vortex current. Probably as a result of this current the sperm nucleus and centrosome are carried deeper into the egg and finally are brought near to the egg nucleus (Fig. 23 *D* and *E*). In the movements of egg and sperm nuclei toward each other it is evident that they are passively carried about by currents in the cytoplasm; the entrance of the sperm serves as a stimulus to the egg cytoplasm which moves according to its preestablished organization.

2. *Cleavage and Differentiation*

When the sperm nucleus has come close to the egg nucleus the sperm centrosome usually divides into two minute granules, the daughter centrosomes, which move apart forming a spindle with the centrosomes at its poles and with astral radiations running out from these into the cytoplasm (Fig. 23 *F*). At the same time the chromatin granules and threads in the egg and sperm nuclei run together into a smooth thick

thread, the *spireme,* which is coiled within the nucleus. At this stage it is sometimes possible to see that the spireme is composed of a series of granules, like beads on a string; these granules are the *chromomeres.* The spireme then breaks up into a number of pieces in the form of short threads or rods (Fig. 24 *C* and *D*); these are the *chromosomes.* The

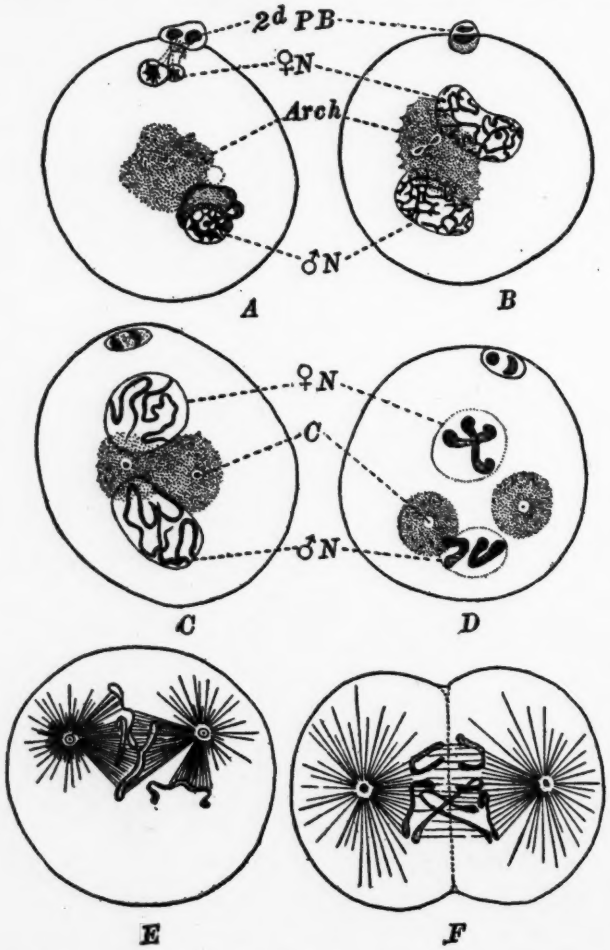

FIG. 24. FERTILIZATION OF THE EGG OF THE NEMATODE WORM *Ascaris;* ♀*N*, egg nucleus; ♂*N*, sperm nucleus; *Arch*, archiplasm; *C*, centrosome; *A*, *B*, approach of germ nuclei; *C*, *D*, formation of two chromosomes in each germ nucleus *E*, *F*, stages in the division of the chromosomes which are split in *E* and are separating in *F*; only three chromosomes are shown in *F*. (From Wilson after Boveri.)

number of these chromosomes is constant for every species and race, though the number may vary in different species. In the thread worm, *Ascaris,* there are usually two chromosomes in the egg nucleus and two in the sperm nucleus (Fig. 24 *D*). In the gastropod, *Crepidula,* there are about thirty chromosomes in each germ nucleus and sixty in the two. Then the spindle and asters grow larger and the nuclear membrane

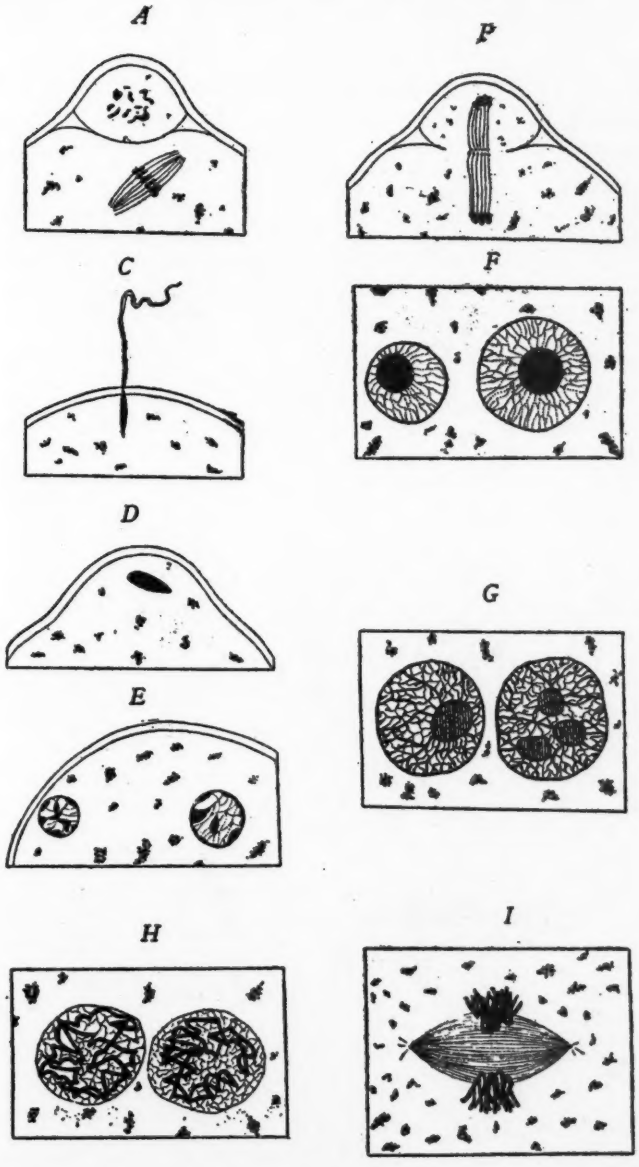

FIG. 25. MATURATION AND FERTILIZATION OF THE EGG OF THE MOUSE. *A*, first polar body and second maturation spindle; *B*, second polar body and maturation spindle; *C*, entrance of the spermatozoon into the egg; *D–G*, successive stages in the approach of egg and sperm nuclei; *H*, formation of chromosomes in each germ nucleus; *I*, first cleavage spindle showing chromosomes from egg and sperm on opposite sides of spindle. (After Sobotta.)

grows thinner and finally disappears altogether, leaving the chromosomes in the equator of the spindle (Figs. 23 *F*, 24 *E* and *F*, 25 *I*).

Each of the chromosomes then splits lengthwise into two equal parts, and in the splitting of the chromosomes it is sometimes possible

to see that each chromomere divides through its middle. The daughter chromosomes then separate and move to opposite poles of the spindle, where they form the daughter nuclei, and at the same time the cell body begins to divide by a constriction which pinches the cell in two

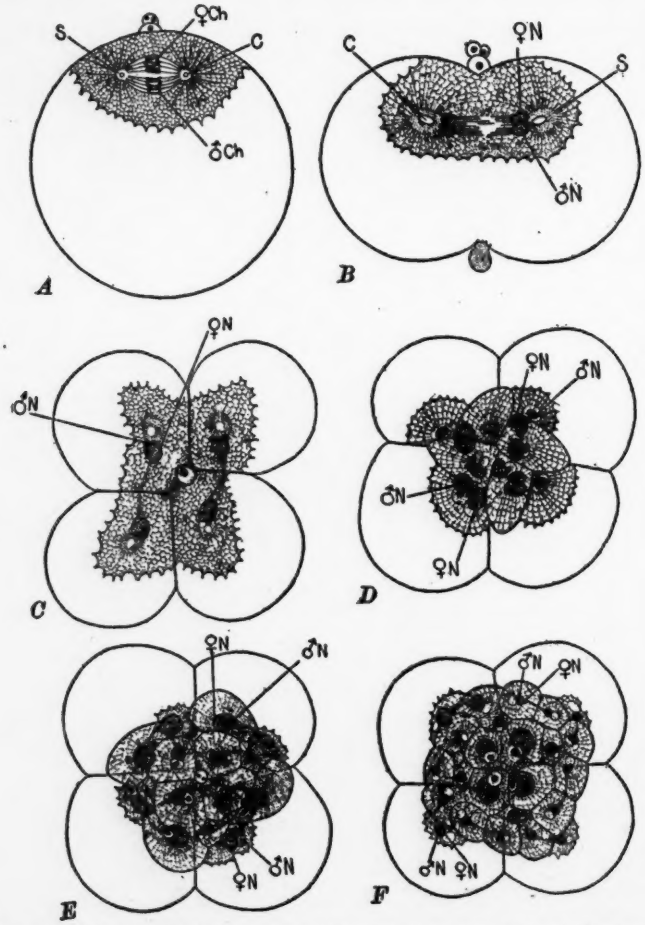

FIG. 26. SUCCESSIVE STAGES IN THE CLEAVAGE OF THE EGG OF MOLLUSK (*Crepidula*), showing the separateness of the male and female chromosomes (♂ *ch*, ♀ *ch*) and the male and female halves of each nucleus (♂*N*, ♀*N*).

in the plane which passes through the equator of the spindle (Fig. 26 *B*). Finally the daughter nuclei grow in size by the absorption of achromatin from the cell body and the substance of the chromosomes is again distributed through the achromatin in the form of threads and granules and thus the daughter nuclei come back to a "resting" stage similar to that with which the division began, thus completing the "division cycle" of the cell.

During the whole division cycle it is possible in a few instances to distinguish the chromosomes of the egg from those of the sperm, and in

every instance where this can be done it is perfectly clear that these chromosomes do not fuse together nor lose their identity, but that every chromosome splits lengthwise and its halves separate and go into the two daughter cells where they form the daughter nuclei. Each of these cells therefore receives half of its chromosomes from the egg and half from the sperm. Even in cases where the individual chromosomes are lost to view in the daughter nuclei those nuclei may be clearly double, one half of each having come from the egg chromosomes and the other half from the sperm chromosomes (Fig. 26 *B*).

At every subsequent cleavage of the egg the chromosomes divide in exactly the same way as has been described for the first cleavage. Every cell of the developing animal receives one half of its chromosomes from the egg and the other half from the sperm, and if the chromosomes of the egg differ in shape or in size from those of the sperm, as is sometimes the case when different races or species are crossed, these two groups of chromosomes may still be distinguished at advanced stages of development. Where the egg and sperm chromosomes are not thus distinguishable it may still be possible to recognize the half of the nucleus which comes from the egg and the half which comes from the sperm even up to an advanced stage of the cleavage (Fig. 26).

At the same time that the maternal and paternal chromosomes are being distributed with such precise equality to all the cells of the developing organism, the different substances in the cell body outside of the nucleus may be distributed very unequally to the cleavage cells. The movements of the cytoplasm of the egg which began with the flowing of the surface layer to the point of entrance of the sperm, lead to the segregation of different kinds of plasms in different parts of the egg and to the unequal distribution of these substances to different cells.

One of the most striking cases of this is found in the ascidian, *Styela,* in which there are four or five different kinds of substance in the egg which differ in color, so that their distribution to different regions of the egg and to different cleavage cells may be easily followed, and even photographed while in the living condition. The peripheral layer of protoplasm is yellow and when it gathers at the lower pole of the egg where the sperm enters it forms a yellow cap. This yellow substance then moves, following the sperm nucleus, up to the equator of the egg on the posterior side and there forms a yellow crescent extending around the posterior side of the egg just below the equator. On the anterior side of the egg a gray crescent is formed in a somewhat similar manner and at the lower pole between these two crescents is a slate blue substance, while at the upper pole is an area of colorless protoplasm. The yellow crescent goes into cleavage cells which become muscle and mesoderm, the gray crescent into cells which become nervous system and notochord, the slate-blue substance into endoderm cells and the colorless substance into ectoderm cells.

Thus within a few minutes after the fertilization of the egg, and before or immediately after the first cleavage, the anterior and posterior, dorsal and ventral, right and left poles are clearly distinguishable, and

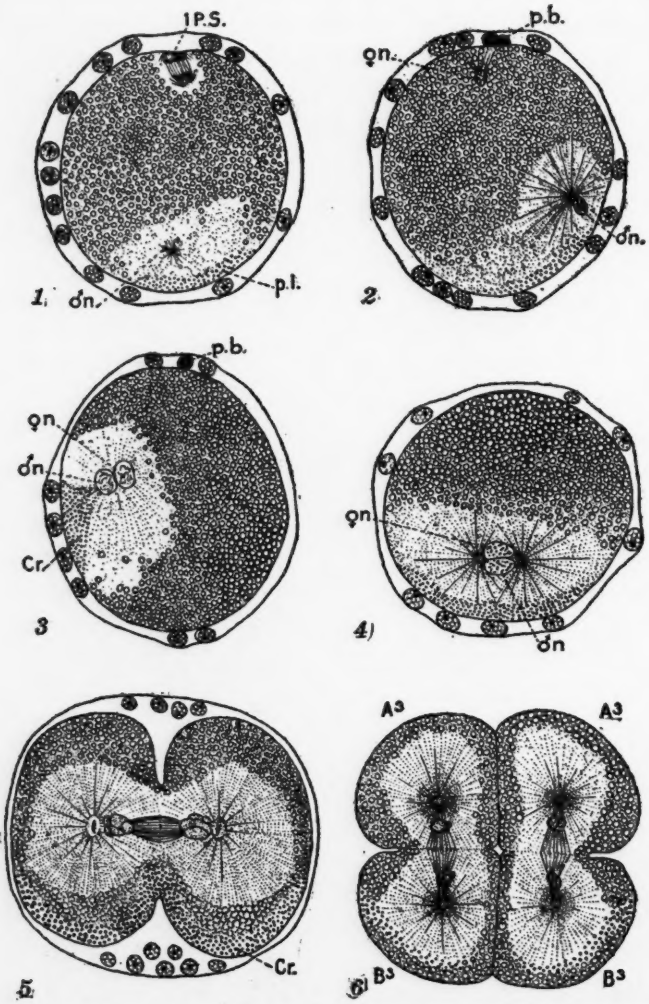

FIG. 29. SECTIONS OF THE EGG OF *Styela*, showing maturation, fertilization and early cleavage; *1 P. S.*, first polar spindle, *p. b.*, polar bodies, ♂*N*, sperm nucleus, ♀*N*, egg nucleus, *p. l.*, peripheral layer of yellow protoplasm, *Cr*, crescent of yellow protoplasm, A_2, A_2, anterior cells, B_2, B_2, posterior cells of the 4-cell stage. In 1 the sperm nucleus and centrosome are at the lower pole near the point of entrance; in 2 and 3 they have moved up to the equator on the posterior side of the egg; in 4 the egg and sperm nuclei have come together and the sperm centrosome has divided and formed the cleavage spindle; in 5 the egg is dividing into right and left halves in 6 it is dividing into anterior and posterior halves.

the substances which will give rise to ectoderm, endoderm, mesoderm, muscles, notochord and nervous system are plainly visible in their characteristic positions.

At the first cleavage of the egg each of these substances is divided into right and left halves (Fig. 29, 5). The second cleavage cuts off two anterior cells containing the gray crescent from two posterior ones containing the yellow crescent (Fig. 29, 6 and Fig. 30, 1). The third cleavage separates the colorless protoplasm in the upper hemisphere from the slate-blue in the lower (Fig. 30, 2). And at every successive cleavage the cytoplasmic substances are segregated and isolated in particular cells,—and in this way the cytoplasm of the different cells comes to be unlike (Figs. 30 and 31). When once partition walls have been

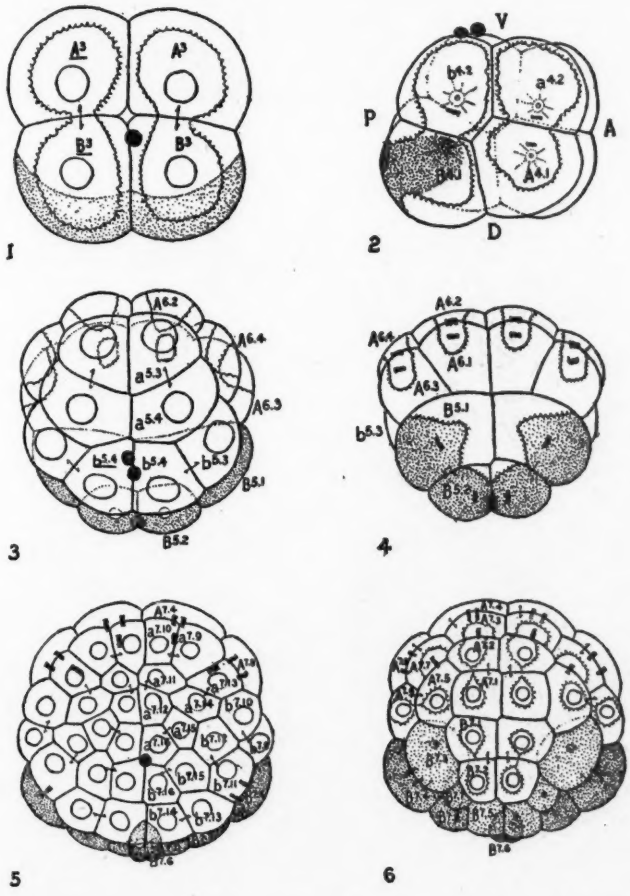

FIG. 30. CLEAVAGE OF THE EGG OF *Styela*, showing distribution of the yellow protoplasm (stippled) and of the clear and gray protoplasm to the various cells, each of which bears a definite letter and number.

formed between cells they permanently separate the substances in the different cells so that they can no longer commingle.

What is true of *Styela* in this regard is equally true of many other ascidians, as well as of *Amphioxus* and of the frog, though the segrega-

tion of substances and the differentiation of cells is not so evident in the last named animals because these substances are not so strikingly colored. Indeed the segregation and isolation of different protoplasmic substances in different cleavage cells occurs during the cleavage of the egg in all animals, though such differentiations are much more marked in some cases than in others.

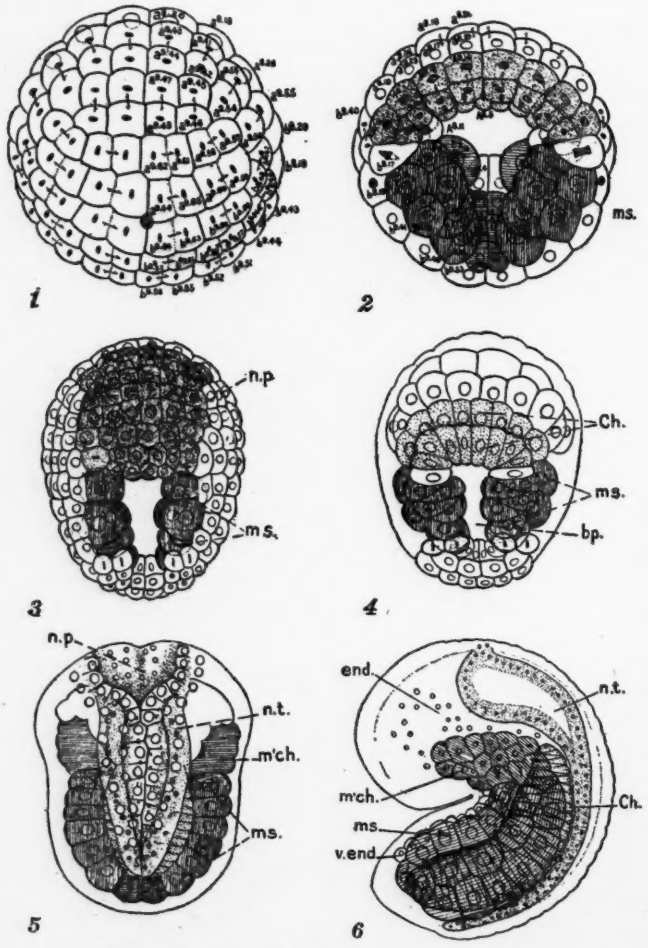

FIG. 31. GASTRULA AND LARVA OF *Styela*, showing the cell lineage of various organs, and the distribution of the different kinds of protoplasm to these organs. Muscle cells are shaded by vertical lines, mesenchyme by horizontal lines, nervous system and chorda by stiples.

This same type of cell division, with equal division of the chromosomes and more or less unequal division of the cell body, continues long after the cleavage stages—indeed throughout the entire period of embryonic development. Sometimes the division of the cell body is equal, the daughter cells being alike; sometimes it is unequal or differential—

but always the division of the chromosomes is equal and non-differential. When once the various tissues have been differentiated the further divisions in these tissue cells are usually non-differential even in the case of the cell bodies.

There can be no doubt that this remarkably complicated process of cell division has some deep significance; why should a nucleus divide in this peculiarly indirect manner instead of merely pinching in two as was once supposed to be the case? What is the relation of cell division to embryonic differentiation? In this process of mitosis, or indirect cell division, two important things take place: (1) Each chromosome, chromomere and centrosome is divided exactly into two equal parts so that each daughter structure is at the time of its formation quantitatively one half the size and qualitatively precisely like its mother structure. (2) Accompanying the formation of radiations, which go out from the centrosomes into the cell body, diffusion currents are set up in the cytoplasm which lead to the localization of different parts of the cytoplasm in definite regions of the cell, and this cytoplasmic localization is sometimes of such a sort that one of the daughter cells may contain one kind of cell substance and the other another kind. Thus while mitosis brings about a scrupulously equal division of the elements of the nucleus, it may lead to a very unequal and dissimilar division of the cytoplasm. In this is found the significance of mitosis and it suggests at once that the nucleus contains undifferentiating material, viz., the idioplasm or germplasm, which is characteristic of the race and is carried on from cell to cell and from generation to generation; whereas the cell body contains the differentiating substance, the personal plasm or somatoplasm which gives rise to all the differentiations of cells, tissues and organs in the course of ontogeny.

Weismann supposed that the mitotic division of the chromosomes during development was of a differential character, the daughter chromosomes differing from each other at every differential division in some constant and characteristic way, and that these differentiations of the chromosomes produced the characteristic differentiations of the cytoplasm which occur during development. But there is not a particle of evidence that the division of chromosomes is ever differential; on the contrary, there is the most complete evidence that their division is always remarkably equal both quantitatively and qualitatively. If daughter chromosomes and nuclei ever become unlike, as they sometimes do, this unlikeness occurs long after division and is probably the result of the action of different kinds of cytoplasm upon the nuclei, as is true, for example, in the differentiation of the chromosomes in the somatic cells as contrasted with the germ cells of *Ascaris* (Fig. 32). But while the chromosomes invariably divide equally, other portions of the nucleus may not do so. Achromatin and oxychromatin, like the cytoplasm, may

divide unequally and differentially, and this is probably a prime factor in development.

On the other hand, the differential division of the cytoplasm is a regular and characteristic feature of ontogeny—indeed the segregation and isolation of different kinds of cytoplasm in different cells is the most important function of cell division in development. Thus we find in the division apparatus of the cell a mechanism for the preserva-

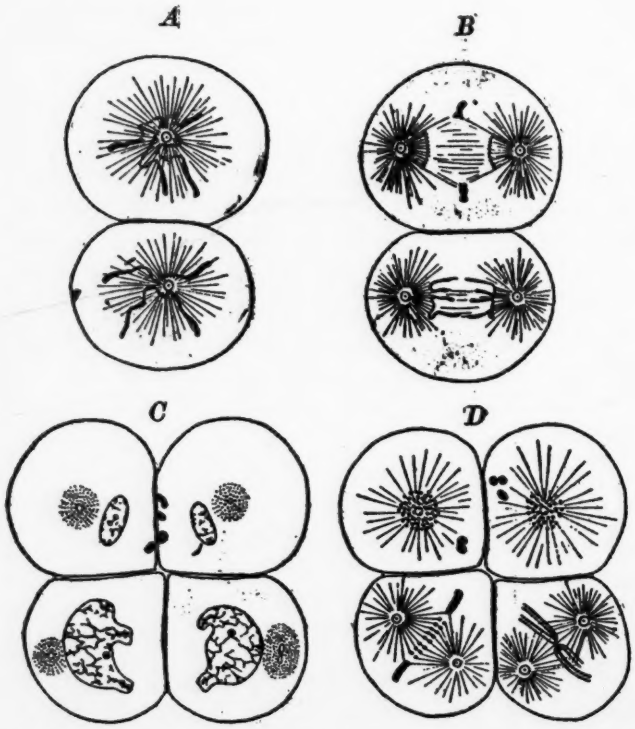

FIG. 32. DIFFERENTIATION OF GERM CELLS AND SOMATIC CELLS IN THE EGG OF *Ascaris*. *A* and *B*, second cleavage division showing that the chromosomes remain entire in the lower cell, which is in the line of descent of the sex cells ("germ track"), but that they throw off their ends and break up into small granules in the upper cells, which become somatic cells. *C*, 4-cell stage, the nuclei in the upper somatic cells being small and the ends of the chromosomes remaining as chromatic masses in the cell body outside of the nuclei, while the nuclei in the lower cells are much larger and contain all the chromatin. *D*, third nuclear division, showing the somatic differentiation of the chromosomes in all the cells except the lower right one, which alone is in the germ track and will ultimately give rise to sex cells. (After Boveri.)

tion in unaltered form of the species plasm, idioplasm or germ-plasm of the nucleus, and for the progressive differentiation of the personal plasm or somatoplasm of the cell body.

3. *The Origin of the Sex Cells*

The sex cells are the latest of all cells of a developing organism to reach maturity, and yet they may be among the earliest to make their appearance. Every sex cell, like every other type of cell, is a lineal descendant of the fertilized egg (Fig. 22), but the period at which the sex cells become visibly different from other cells varies from the first cleavage of the egg in some species to a relatively advanced stage of development in others.

(*a*). *The Division Period. Oogonia and Spermatogonia*

When the primitive sex cells are first distinguishable they differ from other cells only in the fact that they are less differentiated; they have relatively larger nuclei and smaller cell bodies—a condition which is indicative of little differentiation of the cell body since the products of differentiation such as fibres, secretions, etc., swell the size of the cell body, but do not contribute to the growth of the nucleus. These primitive sex cells or *gonia* divide repeatedly, but the *oogonia* grow more rapidly and divide less frequently than the *spermatogonia*. As a result of this difference in the rate of growth and division the spermatogonia become much smaller and immensely more numerous than the oogonia. This period in the genesis of the sex cells is known as the *division period* (Fig. 22).

(*b*). *The Growth Period. Oocytes and Spermatocytes*

This period of rapid cell divisions is followed by a period of growth without division during which the developing sex cells are called *primary oocytes* or *spermatocytes*. This growth period may be very long in the case of the oocytes, lasting, for example, in the human female from the time of birth to the end of the reproductive period; during this long time the oocytes in the ovary probably never divide—there are as many of them at birth as at any later time; during this period of growth the ovarian egg becomes relatively large, in some animals, *e. g.*, birds, the largest of all cells. The growth period of a spermatocyte lasts for a briefer time than does that of an oocyte so that the former remains relatively small (Fig. 22).

All of the cell divisions which take place during the division period are of the usual kind, in which every chromosome splits lengthwise into two and the two halves then separate and move to opposite poles of the spindle where they break up into threads and granules and form the daughter nuclei, as is shown in Fig. 24. But during the growth period of the oocytes and spermatocytes the chromosomes form a closely wound coil of long chromatin threads (Fig. 33), and when these threads uncoil later it is seen that the chromosomes have united in pairs (Figs. 33 *D* and *E*, 34 *B*, 35 *B*); this process is known as *synapsis*, or the conjuga-

tion of the chromosomes, and there is evidence that one member of each synaptic pair is derived from the father, and the other from the mother. The union of these chromosomes is probably not so close that they lose their identity, though there may possibly be some interchange of substance between them. By this union of the chromosomes into pairs the number of separate chromosomes is reduced to half the normal number; if there are usually 4 chromosomes, as in *Ascaris,* they are reduced to 2 pairs; if 48 chromosomes, as in man, there are 24 of these pairs.

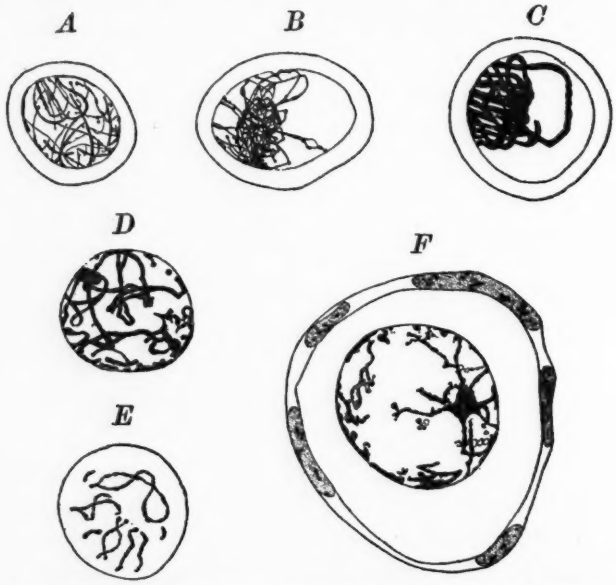

FIG. 33. DIFFERENT STAGES IN THE DEVELOPMENT OF THE EGG OF THE RABBIT. *A,* at the beginning of the growth period showing slender chromatic threads in the nucleus; *B,* later stage in which these threads ball up and parallel threads conjugate forming the shorter, thicker thread shown in *C; D* and *E,* segmentation of the long thread into chromosomes (?) each of which shows its double nature; *F,* later stage in which the distinctions of the chromosomes is temporarily lost. (After Winiwarter.)

In the conjugation of the chromosomes it is plain that, generally speaking, those chromosomes which are similar in shape and size unite; big chromosomes unite with big ones, little ones with little ones, and those of peculiar shape with others of similar shape (Figs. 34 *B,* 35 *B*). It is probable that the two members of a pair of conjugating chromosomes are homologous not merely in shape and size but also in function, though this homology does not amount to identity.

In some instances it can be proved that one member of each conjugating pair of chromosomes comes from one parent and the other from the other parent, and it is probable that this is always true. In every cell of every individual which has developed from a fertilized egg there are two full sets of chromosomes, one of which came from the sperm and the other from the egg; but when this individual in its turn produces

germ cells homologous chromosomes of each set unite in pairs during the growth period.

These synaptic pairs are the *bivalent chromosomes,* and in addition to showing the line of junction by which they are united they frequently show a longitudinal split through the middle of each chromosome and

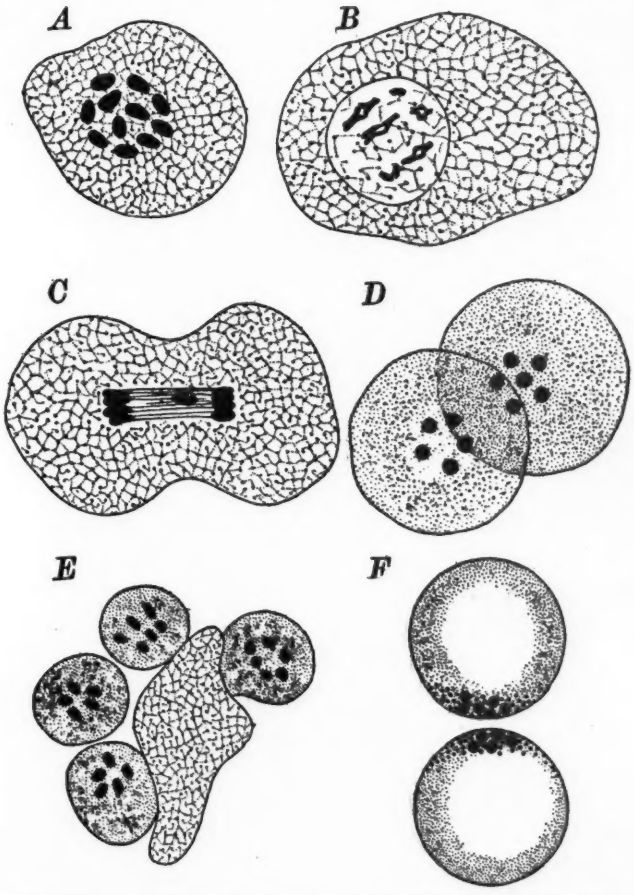

FIG. 34. SPERMATOGENESIS OF A NEMATODE WORM (*Ancyracanthus*). *A*, chromosomes of sperm mother cell, 11 in number, before their union into pairs; *B*, early stage of first division; 10 of the chromosomes have united into 5 pairs and each of these has split lengthwise; 1 chromosome remains unpaired; *C*, first maturation division after the 5 pairs of chromosomes have pulled apart; the unpaired chromosome is going entire to one pole of the spindle; *D*, two cells resulting from this division, one containing 5 and the other 6 chromosomes; *E*, four cells resulting from the division of two cells like *D*, in which each chromosome has split into two so that two of the cells contain 5 and two contain 6 chromosomes. (After changing into spermatozoa, one containing 5 and the other 6 chromosomes. (After Mulsow.) *F*, two of these cells

at right angles to the line of junction. It thus happens that these bivalent chromosomes are frequently four-parted and such four-parted chromosomes are known as *tetrads* (Figs. 34 *B*, 35 B).

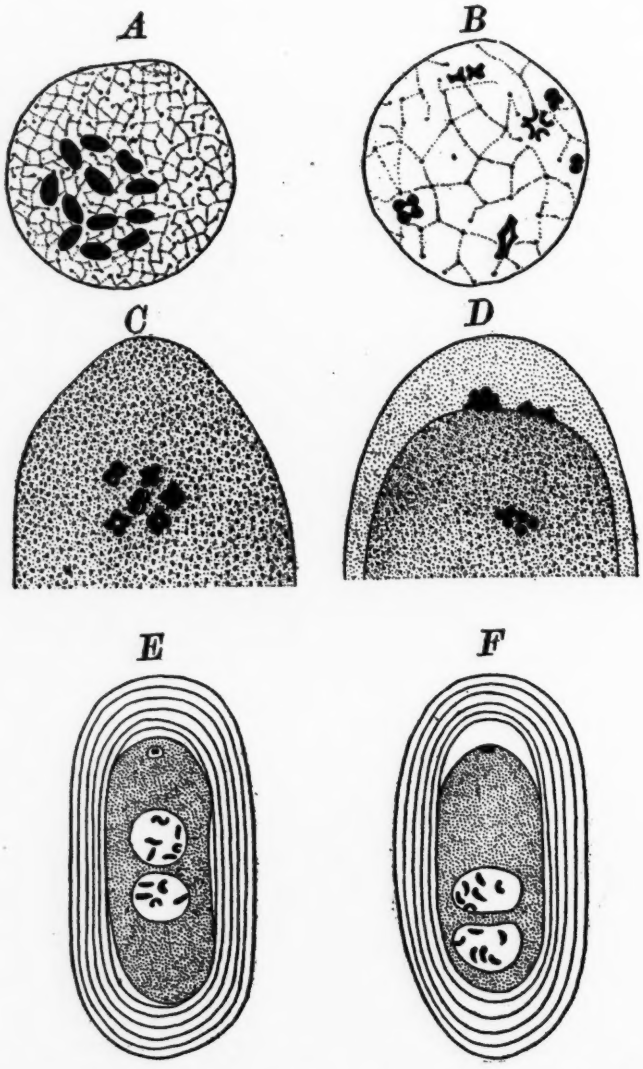

FIG. 35. OOGENESIS OF A NEMATODE WORM (*Ancyracanthus*). *A*, egg mother cell containing 12 chromosomes before their union into pairs; *B*, early stage of first maturation division; all the chromosomes have united into 6 pairs, each of which has split in two so that the pairs are really four-parted (tetrads); *C*, the six tetrads in the first maturation division; *D*, egg containing 6 chromosomes, after both first and second maturation divisions; the eliminated chromosomes are shown as the polar bodies at the margin of the egg; *E* and *F*, eggs after fertilization; the egg nucleus is above and contains 6 chromosomes, the sperm nucleus below and contains 5 chromosomes in one case and 6 in the other; the former becomes a male with 11 chromosomes, the latter a female with 12 chromosomes.

(*c*). *The Maturation Period*

Finally at the close of the growth period both oocyte and spermatocyte undergo two peculiar divisions one following immediately after the

other, which are unlike any other cell divisions. These are known as the first and second maturation divisions and they are the last divisions which take place in the formation of the egg and sperm. In one or the other of these two maturation divisions the pairs of chromosomes separate along the line of junction, one member of each pair going to one pole of the spindle and the other to the other pole, so that in each of the daughter cells thus formed only a single set of chromosomes is present (Fig. 34 *C* and *D*); but since the position of the pairs of chromosomes in the spindle is a matter of chance it rarely happens that all the paternal chromosomes go to one pole and all the maternal ones to the other; thus each of the sex cells comes to contain a complete set of chromosomes though particular individual chromosomes may have come from the father while others have come from the mother. There is reason to believe that homologous chromosomes show general resemblances but individual differences, and consequently when the members of each pair separate and go into the sex cells, these cells differ among themselves because the individual chromosomes in different cells are not the same.

In this way the number of chromosomes in the mature egg or sperm comes to be one half the number present in other kinds of cells, and when the egg and sperm unite in fertilization the whole number is again restored. The double set of chromosomes is known as the *diploid* number, the single set as the *haploid* number, and the maturation division in which this reduction from the double to the single set takes place is the *reduction division*. It is generally held that this reduction takes place in the first of the two maturation divisions (Fig. 34, *C, D*), and that the second of these divisions is like an ordinary mitosis in that each chromosome splits into two and the halves move apart, such a division being known as an *equation division* (Fig. 34 *E*), but it is possible that some chromosome pairs undergo an equation division in the first maturation mitosis and a reduction division in the second, while other chromosome pairs may reverse this order.

It is an interesting fact that long before the reduction of chromosomes had been actually seen Weismann maintained on theoretical grounds that such a reduction must occur, otherwise the number of chromosomes would double in every generation, and he held that this reduction must take place in one of the maturation divisions; this hypothesis of Weismann's is now an established fact.

As the result of these two maturation divisions four cells are formed from each cell (spermatocyte or oocyte) of the growth period. In the spermatogenesis each of these four cells is transformed into a functional spermatozoon (Fig. 34 *E*), by the condensation of the nucleus into the sperm head and the outgrowth of the centrosome and cytoplasm to form the tail. In the oogenesis only one of these four cells becomes a func-

tional egg while the other three are small rudimentary eggs which are called *polar bodies* and which take no further part in development (Fig. 23, *D–F*). The fertilization of the egg usually takes place coincidently with the formation of the polar bodies—and so we come back once more to the stage from which we started, thus completing the life cycle.

4. *Sex Determination*

In the formation of the sex cells one can frequently distinguish at an early stage, differences between the larger oogonia and the smaller and more numerous spermatogonia; this difference is the first visible distinction in the development of the two sexes. In the case of the human embryo this distinction can be made as early as the fifth week, and it is evident that the real causes of this difference must be at a still earlier period of development.

The cause of sex has been a favorite subject of speculation for thousands of years. Hundreds of hypotheses have been advanced to explain this perennially interesting phenomenon. The causes of sex determination have been ascribed to almost every possible external or internal influence and the world is full of people who think they have discovered by personal experience just how sex is determined. Unfortunately these hypotheses and rules are generally founded upon a few observations of selected cases. Since there are only two sexes the chances are that any hypothesis will be right half the time, and if only one forgets the failures of a rule and remembers the times when it holds good it is possible to believe in the influence of food or temperature or age, of war or peace or education on the relative number of the sexes, or on almost any other thing. By statistics it has been shown that each of these things influences the sex ratio, and by more extensive statistics it has been proved that they do not.

This was the condition regarding the causes of sex determination which prevailed up to the year 1902. Immediately preceding that year it had been found that the kinds of spermatozoa were formed in equal numbers in certain insects; one of these kinds contained a peculiar "accessory" chromosome, and the other lacked it. The manner in which these two types of spermatozoa were formed had been carefully worked out by several investigators without any suspicion of the real significance of the facts. It was shown that an uneven number of chromosomes might be present in the spermatogonia of certain insects and that when maternal and paternal chromosomes united in pairs in synapsis one "odd" chromosome was left without a mate (Fig. 34 *B*). Later, in the reduction division, when the synaptic pairs separated, the odd chromosome went entire into one of the daughter cells, and the spermatozoa formed from this cell contained one chromosome more than those formed from the other daughter cell (Fig. 34 *C* and *D*).

Chiefly because these two kinds of spermatozoa occur in equal numbers McClung in 1902 concluded that this accessory chromosome was a sex determinant. In 1905 Wilson discovered in a number of bugs that while there were two types of spermatozoa, one of which contained, and

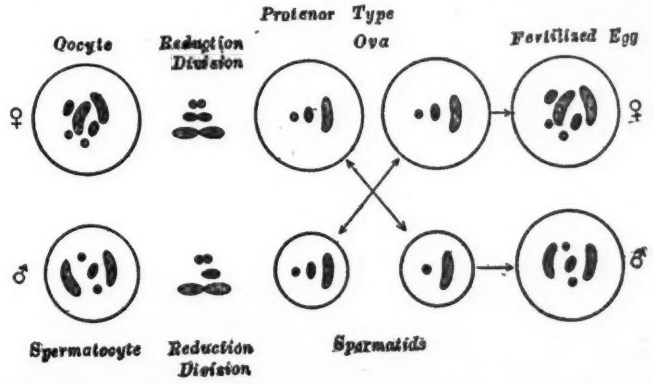

FIG. 36. DIAGRAMS OF SEX DIFFERENTIATION IN THE BUG, *Protenor*. The oocyte contains 6 chromosomes and the spermatocyte 5 chromosomes which are not yet united into synaptic pairs; the "sex" chromosomes are shown in black and white, two are present in the oocyte, but one is present in the spermatocyte. In the reduction division the synaptic pairs separate, giving rise to two types of spermatozoa, one of which has the sex chromosome and the other lacks it; all ova are alike in this regard. If an egg is fertilized by a sperm without the sex chromosome a male results; if fertilized by a sperm containing the sex chromosome a female results. (After Wilson with modifications.)

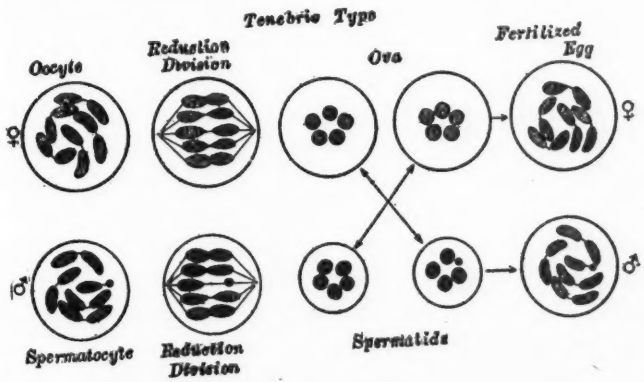

FIG. 37. DIAGRAMS OF SEX DIFFERENTIATION IN THE BEETLE, *Tenebrio*, showing 5 synaptic pairs of chromosomes (there are actually 10 pairs); in the oocyte all pairs are equal in size; in the spermatocyte one pair is unequal. These pairs separate in the reduction division giving rise to two types of spermatozoa and one type of ova; eggs fertilized by one type of sperm give rise to females, those fertilized by the other type give rise to males. (After Stevens with modifications.)

the other lacked, the accessory chromosome, there was only one type of egg, since every egg contained the accessory chromosome, and he pointed out that if an egg were fertilized by a sperm containing an accessory, two accessories would be present in the zygote, this being the condition

of the female, while if it were fertilized by a sperm without an accessory there would be present in the zygote only the accessory derived from the egg (Fig. 35 *E* and *F*, Fig. 36).

In other cases Miss Stevens as well as Wilson discovered that two accessory chromosomes, differing in size, might be present in the male whereas in the female they are of equal size (Fig. 37). In such cases two types of spermatozoa are produced in equal numbers, one containing a large and the other a small accessory chromosome, whereas every egg contains one large accessory chromosome. If such an egg is fertilized

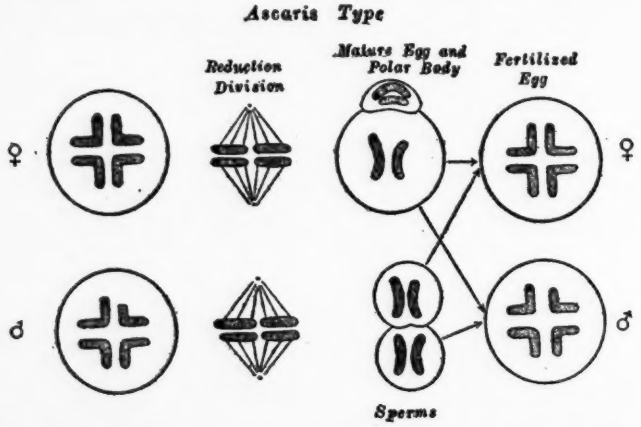

FIG. 38. DIAGRAMS OF SEX DIFFERENTIATION IN THE THREAD WORM, *Ascaris*. The sex chromosomes are here joined to ordinary chromosomes, there being two in the egg mother cell and one in the sperm mother cell. All eggs contain one of these sex chromosomes, while half of the spermatozoa have it and half do not. Eggs fertilized by one type of sperm produce females, those fertilized by the other type produce males. (From Wilson.)

by a sperm containing a large accessory (the *X* chromosome) it gives rise to a female, if by a sperm containing a small accessory (the *Y* chromosome) it gives rise to a male (Fig. 37).

In other animals one may not be able to distinguish separate *X* or *Y* chromosomes and yet such structures may be joined to one or two ordinary chromosomes. This is the case in the thread worm, *Ascaris* (Fig. 38), where two such accessory elements are present in the female, each being joined to the end of an ordinary chromosome, whereas in the male only one such element is present. Here also two classes of spermatozoa are found one with and the other without the accessory element, whereas all ova have this element, and in this case also sex is probably determined by the type of spermatozoon which enters the egg (Fig. 38).

Even in man sex is determined in the same manner according to several recent investigators. There are in the spermatogonia of man 47 chromosomes, accordingly to Winiwarter, one of which is the *X* or accessory chromosome (Fig. 39 *A*). These unite in synapsis into 23

pairs, leaving the *X* chromosome unpaired (Fig. 39, *B*) and in the reduction division the pairs separate, while the *X* chromosome goes entire into one of the daughter cells, which consequently contains $23 + X$ chromosomes, whereas the other daughter cell contains 23 chromosomes (Fig. 39 *C* and *D*). The former gives rise to spermatozoa with 24 chromosomes, the latter to spermatozoa with 23 chromosomes. In the female there are probably 48 chromosomes, according to Winiwarter, there being two *X* chromosomes, one from each parent, and after the reduction divisions every egg contains 24 chromosomes. If an egg is fertilized by a sperm containing 24 chromosomes an individual with 48 chromosomes, or a female, is produced; if fertilized by a sperm with 23 chromosomes an individual with 47 chromosomes, or a male, results (Fig. 39).

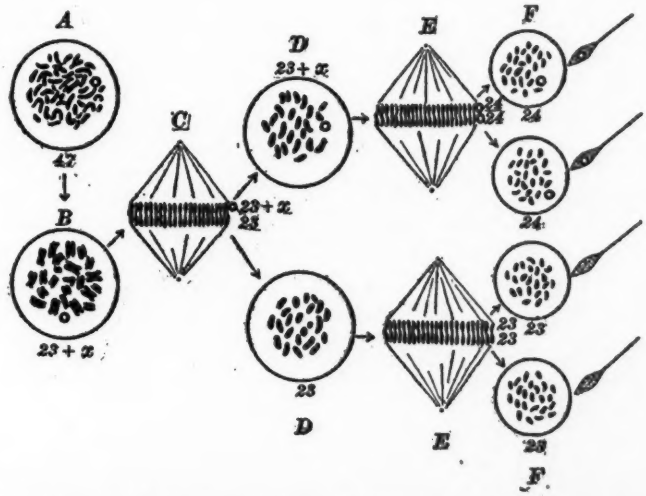

FIG. 39. DIAGRAMS OF SEX DIFFERENTIATION IN MAN. *A*, spermatogonium with 47 chromosomes one of which is the "sex" chromosome. *B*, spermatocyte showing 23 synaptic pairs and a single unpaired "sex" chromosome. *C*, reduction division in which the synaptic pairs separate while the sex chromosome does not divide, consequently the second spermatocytes *D* and *D'* contain respectively $23 + X$ and 23 chromosomes. *E* and *E'*, second maturation division in which every chromosome divides, giving rise to two equal classes of spermatids and spermatozoa, one of which has 24 chromosomes and the other 23. If an egg containing 24 chromosomes is fertilized by a sperm with 24, a female with 48 chromosomes is produced; if an egg with 24 chromosomes is fertilized by a sperm with 23, a male results. (From Morgan after Winiwarter.)

It must be said that other investigators, notably Guyer and Montgomery, have not found 47 chromosomes in the spermatogonia of man, but 23. Since both the latter investigators worked on negroes whereas Winiwarter worked on white men it has been suggested quite recently by Morgan and Guyer that there may be twice as many chromosomes in the white race as in the black. A similar condition in which one race has twice as many chromosomes as another race of the same species is

found in two races of the thread worm, *Ascaris megalocephala,* but it is still too soon to affirm that this is true of white and black races of man, though the facts seem to point in that direction.

Similar correlations between chromosomes and sex have been observed in more than one hundred species of animals belonging to widely different phyla. In a few classes of animals, particularly echinoderms and birds, the evidence while not entirely convincing seems to point to the fact that two types of ova are produced and but one type of spermatozoa; but the general principle that sex is determined by the chance union of male-producing or female-producing gametes is not changed by such cases.

On the other hand, there are many observations which seem to indicate that the sex ratio may be changed by environmental conditions acting before or after fertilization and that therefore sex is determined by extrinsic rather than by intrinsic causes. Most of these observations, as already remarked, are now known to be erroneous or misleading, since they do not prove what they were once supposed to demonstrate. But there remain a few cases which can not at present be explained away in this manner. Perhaps the best attested of these are the observations of R. Hertwig and some of his pupils on the effects of the time of fertilization on the determination of sex. If frog's eggs, which are always fertilized after they are laid, are kept for some hours before spermatozoa are mixed with them, or if the female is prevented for two or three days from laying the eggs after they have entered the oviducts, the proportion of males to females is enormously increased. Hertwig attempts to explain this extremely interesting and important observation as due to the relative size of nucleus and cytoplasm of the egg; but in general this nucleus-plasm ratio may vary greatly irrespective of sex and there is no clear evidence that it is a cause of sex determination.

Miss King, also working on frog's eggs, has increased the proportion of males by slightly drying the eggs or by withdrawing water from them by placing them in solutions of salts, acids, sugar, etc., but the manner in which drying increases the proportion of males is wholly unknown.

Extensive statistics show that in many animals including man more males are born than females, whereas according to the chromosome theory of sex determination as many female-producing sperm are formed as male-producing. It is possible to explain such departure from the 1:1 ratio of males and females in conformity with the chromosome theory if one class of spermatozoa are more active or have greater vitality than the other class, or if after fertilization one sex is more likely to live than the other. In the human species it is known that mortality is greater in male babies before and after birth than in female babies, and if before fertilization the activity or vitality of male-producing spermatozoa is greater than that of female-producing ones it would ex-

plain the greater number of males than of females. In certain insects it is known that females only develop from fertilized eggs, and in one of these cases, viz., *Phylloxera,* Morgan has discovered that this is due to the fact that all the male-producing spermatozoa degenerate and that only female-producing spermatozoa become functional. Possibly experimental alterations of the sex ratio, such as Hertwig, King and others have brought about, may be explained in a similar way. At least the chromosomal theory of sex determination is so well established in so many cases and has been found to be true in so many instances where at first it seemed impossible of application, that it ought not be abandoned until unmistakable evidence can be adduced against it. For the present at least we are justified in concluding that sex is irrevocably determined at the time of fertilization.

(*To be concluded.*)

THE ORIGIN OF NITRATE DEPOSITS

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THE origin of all nitrate deposits was at one time accounted for by oxidation. The theory was held that the production of nascent nitrogen through the decomposition of organic matter caused a union to take place between the oxygen of the air and the nitrogen of the organic matter. Since then it has been shown that nitrates may be produced in various ways, and new theories are still being advanced from time to time to explain the origin of the nitrate deposits which occur in various parts of the world. The fact that different views have often been advanced to explain the origin of the same deposit has given rise to a great deal of discussion, and there still exists a wide difference of opinion as to the source from which the nitrogen may have been derived. By the source in this case is usually meant the preceding form in which the nitrogen appeared rather than the ultimate source of the nitrogen since this is generally admitted to be the atmosphere. The object of the present writing is to give a review of the various theories which have been advanced in this connection.

The fixation of nitrogen, that is, the transformation of elementary nitrogen into a combined state, may be brought about in the laboratory in a great many ways. Some of these processes have been shown to be profitable commercially and large quantities of nitrates and other compounds of nitrogen are now being manufactured in Europe and likewise in Canada, at Niagara Falls, but up to the present no commercial plant for the manufacture of "atmospheric nitrogen" products has yet been established in this country. These various processes of fixing nitrogen artificially may be grouped into four classes according as there is produced (1) nitrates or nitrites, (2) ammonia, (3) nitrides, or (4) cyanamid and its related compounds.

The fixation of nitrogen in nature also takes place in a number of different ways, but, unlike the technical operations just referred to, this is brought about principally by organic processes. Small amounts, however, are also fixed in nature by inorganic processes in a way analogous to some of the artificial methods, and in this way there are formed nitrates or nitrites, ammonia and nitrides.

The best known case of the inorganic fixation of nitrogen in nature occurs when nitric acid is formed in the air by lightning discharges at the time of thunder storms. The quantity of nitrogen which is combined

in this way seems to differ in different parts of the world. In British Guiana during a period of twenty years the quantity so formed amounted each year on an average to 1.88 pounds per acre, while in Utah only 0.356 pounds was obtained annually for a period of three years. As a result of the decay of organic matter on the earth there is usually present in the air a sufficient quantity of ammonia to combine with all the nitric acid formed, although in the tropics the latter may sometimes be in excess. The ammonium nitrate which results from the combination dissolves in the snow and rain and in this way is carried to the earth along with other ammonium salts. Except in some parts of the tropics the total nitrogen recovered in this way is usually several times greater than the nitric nitrogen formed by the electric discharge. At Rothamsted, England, it amounted on an average during a period of eight years to 3.37 pounds per acre annually. At Ottawa, Canada, the average for the past five years amounted to 6.18 pounds per acre.

The quantity of nitrates which is thus formed in the air is small when considered locally, but in the aggregate the amount of combined nitrogen which is thus restored by nature to the surface of the earth is very great and is estimated at about 100,000,000 tons.

Other examples of nitrogen compounds which are not of organic origin are the metallic nitrides and ammonium salts which are found in the vicinity of volcanoes at the time of an eruption. It is probable that they are not carried as such in the fumes of the volcano, but are formed near the surface of the earth through exposure of molten rock to an atmosphere of nitrogen in a way analogous to the manner in which nitrogen is fixed artificially by the Serpek process, which consists in heating an ore of aluminium with carbon in an atmosphere of nitrogen. According to this view, nitrids would be formed first, and then ammonia when the former would come in contact with water. Many analyses have been made of the gases given off by volcanoes in different parts of the world, and free nitrogen has always been an important constituent, but so far as known combined nitrogen has never been reported.

A nitrogen compound of inorganic origin is also to be found in the case of a rare mineral which occurs in some parts of Arizona, and which has the distinction of being the only insoluble nitrate occurring in nature. This mineral to which the name Gerhardtite has been given is a basic nitrate of copper and is supposed to have been formed in the earth by water charged with air percolating over copper ore. It affords an illustration of an unusual way in which the fixation of nitrogen may be brought about.

The organic processes, however, are by far the most important in bringing about the fixation of nitrogen and the formation of nitrates. That nitrogen is one of the principal constituents of plants has been known since the beginning of the last century, but the source of the

nitrogen was a matter of controversy for a long time afterwards. The experiments of some investigators showed that with sterilized soil and with all sources of combined atmospheric nitrogen cut off, the free nitrogen takes no part in the food supply of the plant. Other investigators arrived at just the opposite conclusion. These opposite views led to a great deal of discussion, and it was not until 1888 that Hellrigel was able to account for these conflicting results by growing leguminous plants in nitrogen-free soils. One set of plants was watered with distilled water, while to the other set was added in addition small amounts of leachings, containing only a trace of nitrogen, from a cultivated field. The plants watered with distilled water made but a small growth and soon died of nitrogen starvation, but those watered with the leachings reached a full growth and were found to contain about one hundred times more nitrogen than the seed sown. It was observed that the roots of the latter plants were covered with swellings, or nodules, which contained characteristic organisms while those which were watered with distilled water only had none. Furthermore, no nodules appeared and the plants did not develop when the soil leachings were sterilized before using. The experiments thus showed that the plants which were provided with nodules must have obtained nitrogen through the agency of the microorganisms; that these must have come from the soil leachings; and that they must have the property of fixing the nitrogen of the air. For some unknown reason these bacteria, to which the name *Bacillus radicicola* has been given, do not develop on the roots of non-leguminous plants; consequently, when plants of this kind are grown in the soil and harvested the total quantity of nitrogen present gradually becomes less. The advantage of rotating leguminous plants with crops of this kind thus becomes clear, because when a crop of the former is grown or plowed under as green manure the total nitrogen in the soil is increased. As the plants decay a part of the protein nitrogen of the plant again passes into the elementary state, part changes into ammonia, and a third part changes into nitrates. These changes are brought about by different bacteria, those responsible for the formation of nitrates being called nitrifying bacteria.

The amount of protein nitrogen which is converted into nitrates in the soil by these bacteria varies with conditions and depends on the physical condition of the soil, the quantity of organic matter present, the moisture content and the temperature. A basic element as potash, soda or lime must also be present with which the nitric acid formed may unite. On a limited scale these conditons may be so controlled that large quantities of protein nitrogen may be converted into nitrates, as is still done in India for the production of potassium nitrate to be used in the manufacture of gun-powder. The action of the nitrifying bacteria in thus leading to the formation of nitrates does not bring about any in-

crease in the quantity of nitrogen combined, but simply brings about a transformation from one form to another.

Shortly after the discovery that the bacteria which are associated with the roots of leguminous plants are able to fix nitrogen, a great many experiments were made to determine if other bacteria have a similar function. Very conflicting results were obtained. Some investigators reported that certain bacteria are able to fix nitrogen, while others arrived at an opposite conclusion with respect to the same bacteria. Experiments along this line are still being made. It seems that most of the bacteria in the soil do not bring about any fixation of nitrogen, but there is good evidence that there are two or three kinds in addition to the *Bacillus radicicola* which are able to do this. Unlike the latter, these bacteria do not require the medium of leguminous plants, but may be active in soils which are devoid of growing vegetation. The most important of these bacteria have been called *Azotobacter chroococcum*. It has also been shown that various fungi, algæ and other organisms possess greater or less power of fixing atmospheric nitrogen.

A special study of the amount of fixation which may take place through the activities of these organisms, particularly the *Azotobacter chroococcum,* has been made by Headden[1] and others at the Colorado Agricultural Experiment Station. It was observed that in certain parts of Colorado dark-brown spots occur in which nothing will grow. From the color of the spots it was natural to assume that the cause of the spots was due to the presence of black alkali, or sodium carbonate, which is so commonly met with in the soils of arid and semi-arid countries. An analysis of the soils, however, showed little or no sodium carbonate present, but instead surprisingly large quantities of sodium, calcium and magnesium nitrates. The spots observed were not fixed, but spread rapidly and sometimes covered an area of several acres in extent. Moreover, new spots were noticed to appear in old and new localities. In some cases the amount of nitrogen accumulated, as shown by analysis, amounted to as much as one hundred tons to the acre foot. Arguments were given to show that the nitrates could not have originated with the irrigating water nor from concentration of ground water in the surface layers of the soil. That the spots are the remains of great herds of extinct animals which perished from some unknown cause, was likewise considered improbable for the reason that the areas involved are too large, and that the spots are increasing in size and appearing in localities where they were never before noted. The theory was therefore advanced that the excessive quantities of nitrates were formed *in situ,* through the nitrogen-fixing activity of micro-organisms in the soil.

It was actually shown that the power to fix atmospheric nitrogen is a property common to many cultivated Colorado soils, and that this power

[1] Col. Agri. Expt. Sta., Bull. Nos. 155, 178 and 179.

is not confined to nitrogen fixation in solution, but is manifested in soils as well. The principal nitrogen fixing organisms in the soil were identified as *Azotobacter chroococcum*. These have the power of developing a dark brown color in cultures containing organic matter and a nitrate, but give no color when the nitrate is replaced by organic nitrogen. The rate at which the fixation took place was considered sufficient to account for the formation of the nitrates found in the soil.

Exception has been taken to this view regarding the origin of these nitrate beds by Stewart and Greaves[2] who made a study covering a period of eight years at the Utah Experiment Station of the influence of irrigating water upon the production and movement of nitric nitrogen in the soil. Although the soils upon which the investigations were made were ideally adapted both chemically and biologically to support a rapid biological action, no unusual amounts of nitrates were found. A recalculation of the results reported by Headden showed that in the samples which were taken from the surface of the soil at different points in the same locality and from the same point at different depths, the nitrates and chlorides varied in the same ratio, and that whenever an accumulation of the former took place during a given period, the latter also increased during the same time in the same general proportion. It was therefore concluded that the excessive quantities of nitrates formed in the soils of Colorado were not formed *in situ*, but owe their origin to the same source as the other water-soluble salts.

Further investigations by Headden,[3] however, showed that while large amounts of chlorine generally occur with excessive nitrates, this is accidental rather than necessary, and that on the whole there is no ralation between the amount of nitrates and that of any other class of salts present. Additional evidence is given to show that the concentration in nitrates in brown spots in which nothing will grow is not due to the accumulation of preexisting nitrates, but to the action of microorganisms which are able to bring about the fixation in the soil of atmospheric nitrogen, and that the dark-brown color which is characteristic of the spots is due, not to black alkali, but to the development of pigment by the organisms.

The occurrence of nitrate deposits in caves has long been known. During the War of 1812 and again at the time of the Civil War, the "saltpeter" deposits in the Mammouth Cave, and in other caves in Alabama and Georgia, formed an important source of nitrates required in the manufacture of gunpowder. The origin of these deposits is commonly ascribed to the decomposition of animal remains, and particularly to the excrements of bats. In the southwest small deposits of guano are still to be found in some caves, but almost all deposits which are suffi-

[2] Utah Agri. Expt. Sta., Bull. No. 114.
[3] Col. Agri. Expt. Sta., Bull. No. 186.

ciently large to be of commercial value have been removed for use in the manufacture of fertilizers. Samples taken from some of the caves where the guano has undergone decomposition have been analyzed by the writer and found to run as high as 75 per cent. of potassium nitrate. Other samples have been examined which consisted of very pure elongated white crystals of calcium nitrate, and which had been taken from crevices in a cave. When placed in a humid atmosphere these soon melt in the moisture which they absorb from the air, but may be kept indefinitely in a desiccator.

While guano is usually considered to be the source of the nitrates found in caves, other theories are occasionally advanced to explain the origin of some of the deposits. Thus Hess[4] considers that guano could not be the source of the large store of nitrates which have been taken from the Mammouth Cave at distances of over five miles from any opening which leads to the surface, since bats go, as a rule, but a short distance from the entrance to the cave. Moreover, in the bottom of many caves there are to be found earths from which nitrates can be extracted, but which do not contain any animal remains as would be expected if the nitrates were derived from guano. To explain the occurrence of nitrates in caves of this kind, the view is put forward that the nitrates do not come from guano, but originate in the surface soil above the caves through the oxidation of organic matter by nitrifying bacteria. As the soil in limestone regions is usually loose and porous, the nitrates are considered to be carried down by percolating water and deposited in the floor of the caves. Air currents in and out of the caves would remove the water by evaporation, and the nitrates would consequently remain and would not be washed away so long as the inflow of water did not exceed that lost by evaporation.

A similar explanation is given for the origin of nitrate deposits under overhanging cliffs. Thus, water carrying nitrates dissolved from the soil percolates through the earth and a portion finally oozes out at the surface underneath where it evaporates and leaves the nitrates behind. Being protected from the rain in this position, the nitrates in this way are enabled to accumulate.

The theory advanced by Hess to account for the origin of nitrates in caves has not met with universal acceptance. Nichols[5] has argued that bats do frequent remote parts of caves; that cave earth does contain organic matter; and that the proportion of phosphates to nitrates in the cave earth is much too great to be accounted for on the supposition that they were brought in by percolation from the surface soil. It is considered that while small deposits may be found in the way described by Hess, the great bulk of the nitrates that are found in caves results from

[4] *Jour. Geol.*, 8, 129, 1900.
[5] *Jour. Geol.*, 9, 236, 1901.

the decomposition of bat guano. By leaching of the soluble salts from the guano, the nitrates are removed and may be concentrated in other parts of the cave or distributed elsewhere.

Because of their solubility, it is not to be expected that any large accumulation of nitrates can take place excepting in protected places such as caves, or in arid countries where there is very little rain. In such countries, however, there is very little vegetation, and consequently the organic processes which are of such importance in bringing about fixation of nitrogen in humid countries are able to operate to a much less extent in desert regions. We thus find that in the soil of such regions the total nitrogen present is usually much less than in soils which support a good vegetation.

On the other hand, the soils of desert countries have marked nitrifying powers, with the result that a large percentage of the nitrogen actually present is converted into nitrates. Furthermore, owing to the low percentage of organic matter present and to the porous nature of desert soils the anaerobic dentrifying bacteria are not so active in changing nitrates into free nitrogen, while the lack of vegetation prevents their convertion into protein nitrogen. The nitrates which are formed are thus enabled to accumulate, and either remain in the soil or are transferred by underground waters to other localities where they may be concentrated by evaporation of the water at the surface of the ground. If there has been any introduction into desert localities of organic matter from external sources, as may be brought about by the droppings or remains of animals, the accumulation of nitrates may be correspondingly increased. It thus happens for the reasons given that the largest nitrate deposits are found in desert regions.

In this country few nitrate deposits are to be found apart from those of cave origin. The most extensive so far known occur in San Bernardino and Inyo Counties, California, along the shore lines or bed beaches of what was supposed to be a former sea, but which is now geologically known as Death Valley. The region popularly known as Death Valley is that portion of the valley proper which is below sea level. The territory covered by nitrate beds has been estimated to cover an area of about 35,000 acres. Through erosive agencies the clay beds in which the nitrates were deposited have been worn into buttes and ridges of characteristic shape and color. The hills so formed vary from only 50 feet high to over 300 feet. Samples taken from the niter-bearing strata in the hills, and exposed by erosion, vary all the way from a trace to more than 50 per cent. of nitrates. It is generally agreed that these deposits have not been formed *in situ,* but have resulted from the concentration of nitrates formed from the decomposition and nitrification of animal and plant life which must have existed in the region at the time that the valley was filled with water. Owing to the limited distribution of these

nitrates, they are not considered of much commercial importance, and the same may be said of all other deposits so far discovered in this country.

Small nitrate deposits are also to be found in various other parts of the world, as in the Sahara, in Russian Turkestan, and in Egypt, where nitrate earths occur which contain about 15 per cent. of calcium and sodium nitrates. The earth has long been used locally as a fertilizer, and its use is supposed to be increasing. The source of the nitrates in this region is not known.

All known deposits, however, which occur, like the ones just referred to, in various desert regions throughout the world are insignificant compared with the well-known deposits in the deserts of Atacama and Tarapaca in the north of Chile. These deposits command a great deal of interest, not only on account of their commercial importance, but also for the many attempts which have been made to explain why the quantity of nitrates in this particular region should be so large compared with any other known deposit.

The first shipment of nitrates to Europe from Chile was made in 1825. Since then the annual exportation has continuously increased until in 1912 the total quantity exported amounted to 2,485,860 tons of which 1,925,590 tons went to Europe, 469,100 tons to the United States, and 91,170 tons to other lands.

The arid region in which the nitrates are found extends for about 430 miles between 13° and 25° south latitude and lies between the Andes in the east and the Coast Range on the west. This area lying between the two mountain ranges does not form a continuous valley, but is broken up by transverse ranges into a series of elevated basins or plateaus. These plateaus are generally flat or undulating, and have an elevation from less than 2,500 feet to more than 5,000 feet. They have a general slope from the foot of the Andes towards the Coast Range, and as a result the lowest part of this plateau region, or pampa as it is called in Chile, lies along its western border where it joins the foothills of the Coast Range. It is along this zone that the nitrate deposits occur. The surface of the surrounding region is dry and sandy and vegetation is totally absent.

The nitrate beds as they occur in different parts of this region vary in thickness up to about six feet. They are usually found at or near the surface, but may in some cases be covered with an overburden to a depth as great as thirty feet. The nitrate deposits are never found pure, but are always mixed with sodium chloride and other salts, and are impregnated with insoluble earthy material. Crude nitrate may sometimes run as high as 60 to 70 per cent. of sodium nitrate, but a deposit running 50 per cent. is considered high-grade material. Material containing less than 16 per cent. is too low grade to be mined at a profit at present.

The source of these deposits is a subject which has given rise to a great deal of discussion. Many theories have been advanced to account for the origin of the nitrates, but all appear to fall short of adequately accounting for all the conditions under which the nitrates are found in Chile. It is generally considered that an organic source is the most probable, but there have not been lacking explanations for the formation of these nitrates which have been based on inorganic agencies.

Thus one of the theories advanced is that the nitrates may have resulted from electric storms occuring in the Andes. It has been suggested that the nitric acid which is formed in this way by the oxidation of the nitrogen of the air becomes changed into calcium nitrate on coming in contact with the limestone of the mountains, and that this in turn on being washed down into the pampa region has been converted into sodium nitrate in coming in contact with the sodium salts already existing there. It has also been stated that at certain seasons of the year there is a great deal of static electricity in the air over the desert region, owing to the strong winds and the extremely dry climate, and that the nitric acid which is formed as a result of this condition is carried to the ground by the moisture in fogs which drift in from the sea.

The view has also been advanced that the nitrogen in the Chilean nitrate may have come from nitrogenous fumes given off by volcanoes in the Andes. It has already been pointed out that nitrides and ammonium salts are sometimes found in the vicinity of volcanoes after an eruption, but whether these compounds result from the direct fixation of atmospheric nitrogen near the mouth of the volcano, or from some combined form of nitrogen already present in the earth is not known, but the former view is the more probable. It has been shown, however, that the source of the nitrogen is not organic.

It has been claimed by some that alkali carbonates are able to bring about the fixation of atmospheric nitrogen into nitric acid in the presence of oxidizable matter, and Pissis[6] expressed the opinion that the niter beds in Chile were formed in this way. It was pointed out that the decomposition of feldspar rock in the region of the Andes supplied alkali carbonates, while the protoxide compounds of iron which are common in the rocks of the pampa are easily oxidized under ordinary conditions to form peroxide compounds of iron. The view was accordingly put forward that the alkali carbonates in contact with rocks of this kind brought about the oxidation of the nitrogen of the air with the ultimate formation of nitrates.

Perhaps the most far-fetched attempt at an explanation of the origin of these deposits was that presented by a writer[7] in the *Comptes Rendus*

[6] "Nitrate and Guano Deposits in the Desert of Atacama," A. Pissis, London, 1878.

[7] Bordas, *Compt. rend.*, 147, 924, 1908.

a few years ago. It was observed that pieces of glass left on the ground in the vicinity of the saltpeter mines in the Province of Aconcagua, Chile, became colored blue in a short time, while samples of the same glass exposed on the roofs of buildings to the direct rays of the sun remained colorless. This suggested the possibility of the soil in the vicinity being strongly radioactive, which was thought to be confirmed by the action on photographic plates properly protected and subjected to an exposure in the ground for a month. It was suggested that the radioactivity of the soil as indicated by these experiments might have had something to do with the formation of nitrates in this part of Chile. It is now known that all soils are slightly radioactive and to approximately the same extent.

None of these views which have suggested an inorganic mode of formation for the Chilean nitrates have received very general acceptance. Much more credence is given to the theories that the nitrates found in the deserts of northern Chile have resulted from the decomposition of organic matter brought into the basins in which they are found from outside sources.

One of the most popular of these theories suggests sea-weeds as the source of the nitrates. The explanation is given that in past ages the pampa regions were sea beaches, and that an enormous amount of sea-weed was piled up on them. In course of time the beaches were elevated above sea-level, and the collected sea-weeds in decaying under arid conditions decomposed in such a way that the nitrogen present was converted into nitrates, and the iodine into iodates. It may be pointed out in this connection that immense groves of giant kelps are now to be found along the Pacific Coast of North America, and that the proportion of iodine to potash in the dry plants is about the same as is to be found in the crude niter of Chile. The ratio of nitrogen to potash in the former, however, is very much less than in the latter.

There are many objections which may be offered to this theory. Thus, if the niter came from sea-weed it must necessarily contain bromine as well as iodine, since both are present in this source, and there is no known natural process which can bring about the separation of bromides and iodides. So far as known, however, bromine has not been found in any of the nitrate deposits of Chile; whereas, from analyses made by the writer, the bromine in the giant kelps of the Pacific, for example, is of the same order as the iodine.

Again, sea shells are never found in the nitrate beds, and the stones in the neighborhood are sharp and jagged and show no signs of being worn by water as they must necessarily have been if they had at one time existed on a sea beach.

Perhaps the best known theory which has been advanced to explain the origin of these nitrates is that they have been derived from the

decomposition of ancient guano deposits. In defending this theory Penrose[8] has assumed, in the same way as those who favor a marine origin for the nitrates, that the pampa region was once a part of the ocean bottom, but as the region gradually rose it became a more or less enclosed basin. At this time guano beds were supposed to have been deposited along the borders of these waters, just as they are now deposited in the neighboring shores of the Pacific. It is considered quite possible that marine plants might also have collected in the basin at the same time, and that these constituted the source of the iodine, although it is pointed out that this element might also have originated in minerals, or mineral springs occurring in the region. The formation, as suggested, of inland basins of sea-water, which would ultimately evaporate, would furnish also a source for the common salt associated with the nitrates, as well as for the soda of the nitrates.

The guano theory, however, has been objected to on the ground that no accumulation of phosphate has ever been found in the nitrate country, and such must necessarily occur in amount corresponding to the nitrates if the latter have been derived from guano. It is argued, on the other hand, that such phosphates may actually exist, but that they have not yet been discovered, and it is further explained that the absence of the remains of birds and of sea shells may be accounted for on the ground that sufficient time has elapsed since the beds were deposited to admit of the decay of all such materials.

There is still, however, a further objection which applies to both the sea-weed and guano theories. Thus, if the region was at one time a sea-beach it must have taken ages, as Newton has pointed out, for the nitrate pampa to be elevated to its present level. During these ages the region must have passed through varying climatic conditions, including most probably rains. It has, therefore, been argued that the nitrate deposits are, geologically speaking, of very recent origin.

In suggesting another organic source from which the nitrates may have been derived, Kuntze has called attention to the fact that vicuñas, and llamas, which are at home in this portion of the Andes, have the peculiar habit of always depositing their manure in one and the same place. Immense herds of these animals are supposed to have roamed over the region from time immemorial, each herd having a definite dunging place at some convenient point. As the manure accumulated its nitrification would progress rapidly under the prevailing arid conditions. The common salt would be derived from the urine and excrements, while the decomposition of rocks throughout the region is considered sufficient to account for all other salts occurring in the crude niter.

Newton[9] is of the opinion that the source of the nitrates is the

[8] *Jour. Geol.*, 18, 1, 1910.
[9] *Jour. Soc. Chem. Ind.*, 19, 408, 1900.

organic matter occurring in the soil of the great plain lying between the nitrate beds and the Andes. It is pointed out that there exists in this region all the conditions which favor the rapid conversion by nitrifying bacteria of the nitrogen of organic matter into nitrates. The soil is porous and basic in its nature, and contains organic matter chiefly of ancient vegetable origin; the temperature is high and, on account of the absence of rain, there is no growing vegetation to absorb the nitrate, and therefore it must accumulate. The mountain floods which swamp the plain once in every seven or eight years are considered chiefly responsible for transporting and concentrating the nitrates from the superficial layers of the pampa soil to the lower western part of the pampa region where the deposits are found. The nitrate deposits are thus looked upon as the concentrated fertility of the thousands of square miles of land between the watershed of the Andes and the Coast Range. It is admitted that electrically generated atmospheric nitrate may also be present.

Headden[10] has suggested that the nitrates of Chile may have been formed by the direct fixation of the nitrogen of the air by nitrogen fixing bacteria in the same way as accumulations of nitrates have been shown to have been formed in certain soils of Colorado.

It is apparent from the views which have thus been advanced to explain the origin of the Chilean nitrates that no single theory has yet been proposed which is adequate to account for all the conditions under which the deposits are found, and it seems most probable, as some have suggested, that instead of being formed in one way only, the nitrates owe their origin to several sources.

[10] Col. Agr. Expt. Sta., Bull. No. 155.

ETHNIC FACTORS IN INTERNATIONAL RELATIONS

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THERE are many factors which influence international relations. Among the most important are language, culture, religion and commerce. If the peoples of two countries speak the same language intercourse between them is much easier and sympathetic relations are likely to exist between them. If two nations are of about the same culture with respect to the development of science and art, the diffusion of knowledge, moral standards, etc., this culture is likely to serve as a bond of union. But if the cultural differences are great they may give rise to a feeling of antipathy, or, to say the least, the one nation is almost certain to look down upon the other nation as being of a lower grade of culture. If two nations are of the same religion this may serve as a bond of union. But if they are of different religions this difference may give rise to hostility, especially if one or both of these religions are of a militant sort. If two nations have commercial relations which are to the mutual benefit of both they are almost certain to remain on friendly terms with each other. But if they are rivals in commerce such rivalry is very likely to lead to hostility and sometimes to war.

In this article we are to discuss the part played by ethnic factors in international relations. That is to say, we shall try to ascertain to what extent and how ethnic differences between the peoples of nations affect the relations of those nations towards each other. These differences are with respect to external anatomical characteristics such as stature, facial features, the color of the skin, the character of the hair, etc., and with respect to the internal organs, such as the brain, and the nervous system in general, the heart, lungs, etc., all of which play a part in determining the psychic characteristics of a people. It is, however, very difficult to segregate these factors and to study their effects because they are inextricably mingled with the other factors which have been mentioned. This is true, in the first place, because these ethnic characteristics have their influence in part indirectly through the other factors. That is to say, the language, culture, religion, etc., of a people are determined in varying degrees by these ethnic characteristics. But it is very difficult to determine in any specific case to what extent this is true as compared to the influence of physical environment and such chance circumstances as relations to other peoples.

It is also difficult to determine how ethnic differences influence international relations directly. These differences frequently give rise

to feelings of antipathy, as when the color of the skin or the facial features of one ethnic stock are regarded as ugly, if not repulsive, by another, or when the odor of the skin of one ethnic type is unpleasant to another. But it is evident that in some, if not all, of these cases esthetic, and sometimes moral and religious, ideas as well are involved, so that these antipathies are due in part, and perhaps sometimes entirely, to cultural differences. It would, therefore, be difficult to say in the case of any one of these antipathies whether it would exist on the basis of the ethnic difference alone if the cultural differences were lacking.

It is now evident that this article must consist largely of a study of the degree and permanence of ethnic differences. Since our interest is mainly with respect to the future the discussion may take the form of an attempt to answer two questions. The first is as to whether ethnic differences are sufficiently great to keep the contrasted ethnic stocks permanently in different cultural statuses. The second is as to whether these differences are sufficiently great to prevent a final amalgamation of all the ethnic stocks. In a word it is a question of the possibility and probability of cultural and ethnic uniformity in the future.

There have been many theories as to the part played by ethnic characteristics in determining the culture of a people. At one extreme we find such a writer as Gobineau, who in his treatise on the inequality of the human races tried to prove that there is a great deal of difference between the ethnic stocks as to their capacity for culture. At the other extreme is Boas, who insists that there is practically no difference between the ethnic types in their capacity for culture. It is evident that many of the physical differences between the ethnic types do not imply mental differences. For example, color is in the truest sense only skin deep, and is a racial adaptation to climate. Stature, the shape of the nose, etc., do not in themselves involve specific mental characteristics. But great differences in the brain and the rest of the nervous system, and in certain other of the viscera, would necessarily involve important mental differences and therefore variation in the capacity for culture. Such differences would be in the instinctive, intellectual and emotional make-up of the representatives of the type. Let us see how probable it is that there are such great differences.

There is a certain amount of variation in the size of the brain between the different ethnic types, but it is not at all certain that this variation is sufficiently great to cause any material difference in mental characteristics. This is indicated by the fact that as great variation is to be found in the brains of the members of the most civilized peoples and even among the ablest representatives of these peoples. In the structure of the brain and of its cells, also, there is probably no great variation, though such variations would be of even greater significance than variations in size. In similar fashion, in the rest of the nervous

system there is probably no great variation between the ethnic types. When, however, we come to some of the other viscera, such as the heart and the lungs, controlling the circulatory and respiratory processes, the variations are probably somewhat greater as the necessary result of adaptation to climatic conditions. It is unfortunate that we do not have a larger amount of data, and more accurate data, as to ethnic differences. But what we do know seems to indicate that in the fundamental instinctive characteristics there can be no great differences between the ethnic types. In similar fashion it is doubtful if there can be very much variation in the intellectual capacity of these types. But in the emotional make-up there may be considerable variation, because, according to the prevalent psychological theory as to the nature of emotions, the emotions are determined in large part by the processes of certain of the viscera, such as the heart and lungs, and we have seen that there may be considerable variation in these viscera between the different ethnic types.

Let us now survey briefly the peoples of to-day with respect to this relation between ethnic characteristics and culture. If we take the primitive peoples the first and most important thing to be noted is that these peoples represent all the ethnic types. If there was a close correlation between ethnic characteristics and culture it would be expected that these primitive peoples would belong to one or only certain ethnic types, while the civilized peoples would belong to other types. Furthermore, studies which have been made of certain primitive peoples seem to indicate no great differences in mental characteristics from civilized people. For example, the Cambridge University Anthropological Expedition, which studied some of the most primitive peoples in the world in Australia and Melanesia, found no great differences in the senses and the mental processes of these savages. Dr. Myers, the psychologist of the expedition, came to the conclusion that so far as innate mental capacity is concerned these savages are of about the same grade as European peasants. These facts seem to indicate that the low culture of these primitive peoples is to be attributed principally to environment and to such circumstances as lack of contact with other social groups.

Turning now to the civilized peoples, we find a similar heterogeneity of ethnic type. For example, in Europe we find such heterogeneity in every nation. And yet it is popularly supposed that the culture of each people is due largely to peculiar ethnic characteristics. Thus we hear the culture of the French nation attributed to the "Gallic race," the culture of Germany attributed to the "Teutonic race," etc. But the researches of the ethnologists have revealed the fact that in France, for example, are represented all the principal European ethnic types. Thus in the north of France the Nordic race is predominant, in the central part the Alpine race is predominant, while in the southern part is to be

found in large numbers the Mediterranean race. Thus it is evident how difficult it would be to trace the peculiar features of French culture to peculiar ethnic characteristics. In similar fashion in Germany the Nordic race is most prevalent in the north, while the Alpine race becomes predominant in the south. Such movements as the Pan-Germanic movement and the Pan-Slavic movement are frequently regarded as having a peculiar ethnic significance, but, for example, in the countries which constitute Pan-Slavism, namely, Russia and certain of the Balkan countries, all of the European ethnic types are represented, and also a considerable intermixture of Asiatic blood. The Jews present a similar example of this error. Most of the Jews themselves, as well as most non-Jews, regard the Jewish people as a distinct ethnic type. But ethnological research has shown that there is a great deal of variation between the Jews in different countries, so that it is evident that through intermixture the Jews have lost ethnic unity. The peculiar features of their culture are due to their history and social status rather than to these ethnic characteristics. So far as such movements as Pan-Germanism, Pan-Slavism, Zionism, etc., try to preserve characteristic cultures, they may be of great value. But when they give currency to mistaken ideas of ethnic unity they may do a great deal of harm.

Such mistaken ideas of racial identity have frequently furnished the basis for a national self-consciousness which has led to an assumption of superiority over and hostility towards other races. A realization of the fact that the cultural status of a people is frequently due mainly to its environment and circumstances rather than to its ethnic characteristics would ameliorate these hostile relations. Furthermore, these facts suggest the possibility of a uniformity of culture the world over, which possibility we shall discuss later in this article.

Let us now consider the second question proposed, namely, with regard to the possibility of a final racial amalgamation. This is, of course, largely a question of the feasibility of crossing between the principal ethnic types. There are three of these types, namely, the white or Caucasian, the yellow or Mongolian, and the black or Negro. We have already discussed how antipathies may arise between ethnic types. We have seen these antipathies may arise from cultural differences such as different esthetic ideas. Thus where antipathy is based upon difference in skin color or facial features it is largely, but not entirely, an esthetic matter. Where an antipathy is based upon such a thing as difference in odor it may seem to be innate in its origin and therefore permanent. But even such an antipathy may be partly or largely the result of a difference of taste and therefore due to cultural differences. In fact, it is very difficult to determine whether any antipathy is innate and therefore an insuperable barrier between races. If there is no such innate antipathy, with uniformity of culture all antipathies should disappear.

Such a final racial amalgamation would then seem to be possible. However, there may be other obstacles in the way, and in any case it is not necessarily advisable to work for such an end. This is a question I will discuss a little later.

Let us now consider what have been and are the actual relations between these ethnic types. The whites and the yellows have already mingled to a large extent, so that a considerable proportion of the population of Asia is a cross between the white and yellow races. They have also mixed to a slight extent in Europe. These facts seem to indicate that there is no very serious antipathy between these two types. It is true that at present there is a good deal of hostility between these two races, but this is undoubtedly due in large part to cultural differences and political difficulties.

In his relation to the black, the white has shown a good deal more antipathy. The reasons for this are very evident, since the differences between the white and the black are much more striking in appearance and much more obvious. And yet even between the white and the black there has been a good deal of mixture. In northern Africa the two races have been mixing for thousands of years, and even in Europe we find traces of a slight amount of mixture in the past. In America we find curious differences in the extent to which the white and the black has mixed. In North America, the Anglo-Saxon has, to a large extent, stood proudly aloof from the black, though he has frequently condescended to illegitimate relations with women of color. But in the southern part of North America, in Central and South America, the Portuguese and Spaniards have mixed very largely with the blacks and have displayed comparatively little of the usual antipathy. These facts suggest that this antipathy of the white to the black may not be as fundamental as it appears, and is due to esthetic ideas and cultural differences and also perhaps to the consciousness of the fact that the blacks until very recently were uncivilized and slaves.

Between the yellows and the blacks also there has been some display of antipathy, though it may not be as great as between the whites and the blacks.

I have said nothing about the American aboriginal type. In Latin America this type has been assimilated very largely by the white, while in Anglo-Saxon America it has become almost extinct.

These facts seem to indicate that these racial antipathies are not as innate or as permanent as they seem to be. But this does not mean that there are no other obstacles in the way of racial amalgamation. Each of the ethnic types evolved in a more or less characteristic physical environment, and is, therefore, adapted to such an environment. Thus the negro is adapted in his color, physiological processes and temperament, which is due largely to emotional characteristics, to a tropical cli-

mate. In similar fashion the white is adapted to a temperate climate. Now it may be that neither of these types can become permanently adapted to another climate. The evidence as to this is as yet inconclusive and rather conflicting. But even if such adaptation could finally take place it may hardly be worth while to attempt it, since the process of readjustment would be rather painful. So that for these climatic reasons it may be preferable for the principal ethnic types to remain distinct.

If these types do remain distinct, the very important question arises as to whether they can persist side by side on an equality with each other, or whether some will necessarily remain permanently subject to others. This will probably depend, in part, upon the relative prolificness of these races. That is to say, the more prolific races will, in the long run, have the advantage so far as numbers are concerned, but it will also depend, in part, upon the possibility of a uniform world-wide culture. That is to say, if a race proves incapable of attaining to as high a culture as other races, however prolific it may be, it may still remain subject to another race because of the advantage that a higher culture gives that other race. It is believed by many that this may prove to be the case for the negro race. However, we have seen that there is probably no great difference in intellectual capacity between the different ethnic types. There may, however, be a good deal of difference in emotional characteristics, which play an important part in determining temperament, so that if the negro or any other race remains subject permanently to another race it will probably be due to such emotional characteristics.

We have now discussed very briefly some of the facts and probabilities as to the part played by ethnic factors in international relations. We must now consider what practical deductions may be drawn as to international relations in the future, especially with respect to war. In the first place, a dissemination of knowledge as to the theory of evolution and of the ethnic relations between peoples ought to have much effect in lessening racial prejudice, removing many international antipathies, and promoting international comity. If it were generally known that all the ethnic types have a common ancestry, and that many nations are similar in their ethnic make-up, it should have a good deal of effect towards accomplishing these ends. For example, to take a concrete illustration, if it were generally known that northern France is more like northern Germany ethnically than it is to southern France, and that southern Germany is more like central France ethnically than it is to northern Germany, this knowledge ought to have a good deal of influence in promoting international good feeling between France and Germany.

In the second place, it will probably on the whole and in the long

run be well to develop as fast as possible a world-wide cultural uniformity. I am well aware of the objections that some have to this. They fear that such a dissemination of culture will deprive the whites of their power over many subject races, and may in course of time even give these races the ascendency over the whites. It is true that such uniformity of culture will quite probably lead to the emancipation of these subject races, but this will in all probability be to the benefit of these races and may also prove to be to the benefit of the whites as well. Furthermore, it is hard to believe that such uniformity of culture could ever lead to the subjection of the whites, because the very fact of uniformity would imply equality between the races of the world.

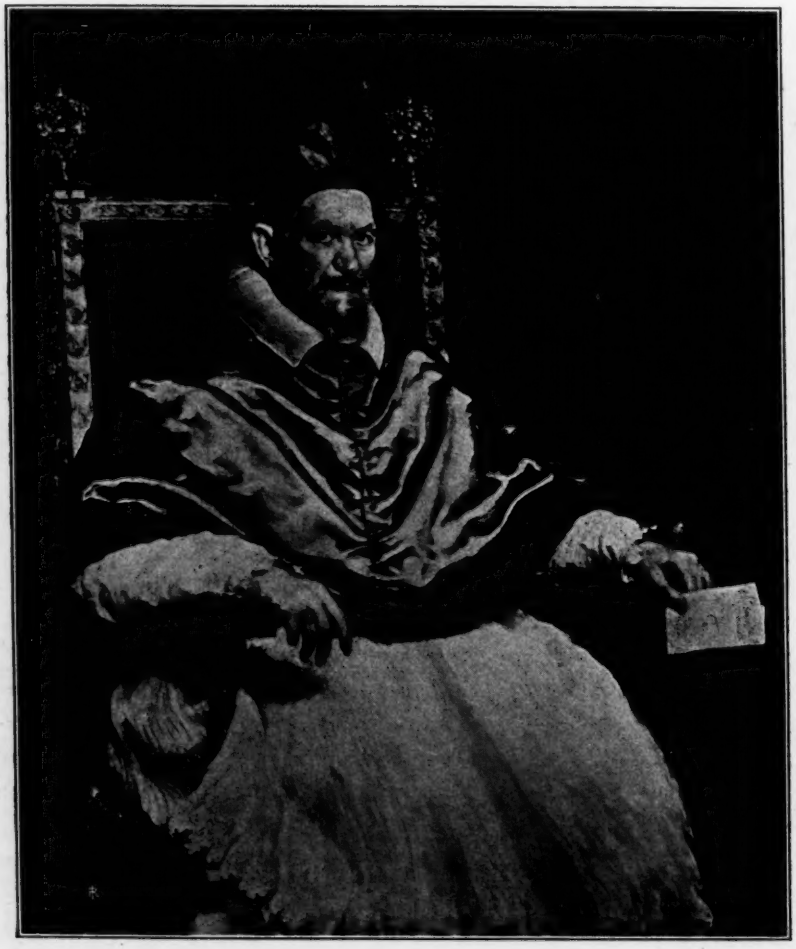
When we turn to the question of a final racial amalgamation, it is hard indeed to draw any practical deductions. There is a great deal of difference of opinion as to the advisability of miscegenation or the crossing of races. It is, of course, to a considerable extent a question of whether the races being crossed are equal in capacity or whether the one is superior to the other. If they are equal it would appear as if there should be no loss as a result of the crossing and if anything a gain. If the one is superior to the other it may lose as a result of the crossing but, on the other hand, the inferior one ought to gain so that the loss ought not to be greater than the gain. However, we have seen that it is hard to determine whether any race is materially superior or inferior to the other races biologically and psychologically so that it may be that the races should be regarded as being practically on an equality for purposes of crossing. But regardless of the question as to whether the races being crossed are equal or not there is the further consideration as to whether their characteristics are such as to make a happy combination. We can not judge very well as to that now but Mendelian investigation may furnish us a basis for judging in course of time.

Non-biological writers usually regard human hybridism as a bad thing when it is the result of a crossing between a so-called superior and a so-called inferior race. Their opinion is based upon the fact that these half-breeds are frequently failures in society. But such failure is usually due to social factors though these writers attribute it to the inborn traits of the half-breeds. Biologists regard hybridism in general as a good thing in the animate world at large and as an important factor in organic evolution. Biologists who have discussed human problems and anthropologists who are well grounded in biology have usually regarded human hybridism as a good thing and as an important factor in human mental and social evolution. So that it is probably true that human hybridism in general is a good thing. However it would not be safe to argue from such a general principle in every specific case. It may be that under some conditions such as have been suggested above miscegenation is not a good thing. Furthermore it is true that if a gen-

eral movement towards a final racial amalgamation began many difficulties would arise as a result of the intimate contact of the races during the long period which this process would take and it might be questioned whether the benefits to be gained by a final amalgamation would more than counterbalance the difficulties of the transition period. And in any case, as we have seen, for climatic reasons such amalgamation may never be possible.

It is now evident that there are three possibilities as to ethnic relations in the future. The ethnic types may always remain distinct, though there will always be a certain amount of crossing between them as there always has been, while the different cultures will also remain distinct. Or the ethnic types may remain distinct but culture will become uniform the world over. Or a final racial amalgamation may take place with a uniform world-wide culture. Uniformity of culture would be the almost inevitable accompaniment of racial amalgamation so that we need not recognize the possibility of such amalgamation with a diversity of culture. I would not dare to express an opinion as to which of these possibilities is most likely to take place. But it is to be hoped in the interests of international peace that in the course of time there will be more or less uniformity of culture at least so far as political organization, moral ideas and systems of law are concerned.

The preceding has necessarily been a very brief discussion of a great subject and I regret very much that I have not the space to apply the broad generalizations which have been suggested to concrete examples. But I hope the discussion has been sufficient to indicate the importance of taking into consideration the ethnic factors in all international relations, as, for example, in the relations of two great European nations such as France and Germany, in the relations of a powerful nation to its subject peoples as the British in India, and in the relations of a great Occidental and a great Oriental country such as the United States and Japan.



PORTRAIT OF INNOCENT X., by Velasquez. Doria Gallery, Rome.

PLEASURE IN PICTURES

By ROSSITER HOWARD

I. Unaccustomed Power of Vision

OUR tastes in pictures do not by any means agree—even those of very wise critics, who ought to know the good from the bad. We might get into all sorts of difficulties with the words *good* and *bad*; but most of us look at pictures because we enjoy them, and our varying choices have some elements in common. These common factors are a sort of minimum wage which we ask in return for our attention, and our pay must be immediately convertible into pleasure.

Perhaps the requirement most nearly universal is that a picture shall look like what it is intended to represent. The popular ideal of art has always been to paint grapes so nearly like the real fruit that the birds will peck at them, and the only excuse for not responding to this widespread demand is that the artist is unskillful.

The people's doctrine has good evolutionary reason back of it. Vision was first developed in the animal by its use in recognizing objects, and recognition is still its chief function and greatest pleasure. The easier the recognition, the greater our sense of capacity; and perhaps the largest element in the enjoyment of pictures is the sense of unaccustomed capacity of vision. We notice this most easily in a portrait that is a "striking likeness;" that is, one that gives us such a sense of the person represented that we react to it more than we should to a view of the person himself, for we are not *struck* by the appearance of our friend. As we look at such a picture we have a visual experience keener than is our habit; our eyes have communicated to us the subject with great force and yet with ease. Though we may say that it is the artist who has been clever, the reason we believe so is that he has lent ability to our eyes. Our feeling is closely akin to the one we have in golf when with an easy swing of our club we feel the ball lifted and shot far beyond our expectation; we experience an unwonted power within ourselves, and a consequent sense of abundant life.

This portrait of "Innocent X." by Velasquez shows us a man with whom we are not acquainted; yet if we should enter the presence of this pope himself he could hardly have upon us the electrifying effect made by his portrait as we come upon it in a cabinet of the Doria Gallery in Rome. It is as though some vital fluid were poured through our veins. Admiration of the artist's ability plays no part in producing this first feeling. The forcefulness which causes our whole organism to react to

"ST. GEORGE AND THE DRAGON," by Carpaccio, Church of San Giorgio degli Schiavone, Venice.

this painting is nothing else than clearness of statement. A photograph with every detail perfected lacks the clearness of this powerful portrait, where the insignificant is blurred or omitted in order that we may grasp at sight the significant. The careful reasoning of a school text-book is not as lucid as the proverbs of "Poor Richard," which cause the mind to leap to a sure conclusion. In a picture the essential quality is clarity; easy recognition is our experience of it.

This is true even in a modern landscape where the rocks and trees of nature are but half revealed by morning mists. Though it seem that the charm lies in the very opposite of clearness, really the artist has presented the clearest possible statement of the conditions of nature which are the spirit of misty dawn. Every element in the landscape which would be the same at any time of day, in all weathers, in all of nature's varying humors, these he has almost obliterated in order that we shall see and feel what he saw and felt that early morning in the shimmering light. Now a man to whom a morning mist is only an obscurity will probably seek in this picture trees and rocks, and the mist will be to him a weariness of the soul; the picture to him is not clear and he finds no pleasure in it. A photograph is more like the place. On the other hand, we might be bored by the photograph's insistent detail, which dissipates the expression of any nature quality; and we should find the painting a jewel of direct presentation of the subject.

The theories of most of those ultra-modern painters who are grouped under the meaningless term "Post-impressionist" are elaborate explanations of a similar aim to isolate some phase of our experience of nature for its simpler, and therefore clearer, presentation. Such a phrase as "the expression of our plastic consciousness" implies but the effort of the Cubist painter to communicate with extraordinary simplicity and force the perception of volume. It is of no importance to this discussion if the artist does not accomplish his purpose; it is the aim that we are seeking.

Narrative pictures introduce an extension of this principle. Here is Carpaccio's "St. George and the Dragon," told with delightful vivacity. We do not believe in dragons, and we may know nothing of St. George; but here is a fight with the hero triumphant, and if we have any imagination we push on that spear as eagerly as we lean down the course while watching a hundred-yards' dash—with this difference, that we doubt the outcome of the race, but feel sure of St. George. All the relations are clear.

Our physical vision is satisfied with easy recognition of hero, horse, dragon and rescued princess; our mental vision interprets and relates these separate objects with unusual facility. Now as intellect is no less the product of evolution than is sight; as the primitive man who enjoyed its exercise developed at the expense of the lazy man; so to-day we are

led forward by delight in mental facility, and the primary pleasure in any clear narrative is the sense of unusual ease in realizing and correlating objects, figures, persons and their experiences.

In proportion as a picture surpasses the usual in the clarity with which it presents its contents—things, thoughts and their relations—do we react to it, feel its force in our own enhanced physical and mental vision. Before a great work our powers seem so much more than adequate that limitation vanishes, and we have a glimpse of the infinite.

II. Constructive Emotions

The largest part of our pleasure in pictures is to see clearly and without effort, but still it makes a difference what we see. A painter, preoccupied with his craft, may care little about the subject, and a critic not infrequently assumes the artisan's viewpoint; but the people have decided wishes. They require pleasantness, and their preference is the result not of stupidity but of instinct. To them an unpleasant subject forcefully portrayed is but the more revolting; their aversion is reflex, and based upon a principle they do not need to understand in order to feel. It is as true in art as it is in nature, that the normally pleasant is what is constructive of life, and the unpleasant is the destructive. Nature's encouragements and warnings which have prevented the animal kingdom from being wiped off the earth ages ago and which have developed man, have been at work also in art among all peoples at all times, producing similar results in absolutely unconnected schools.

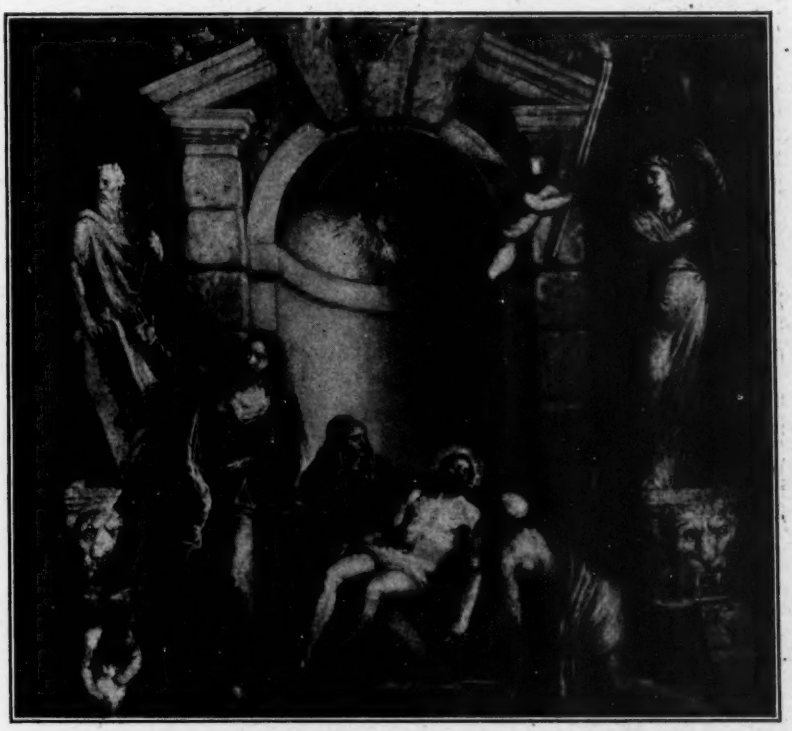
Individual tastes may be warped or even perverted by prejudice of education or other accident of time or place, but underneath is the broad principle that men like what they feel is life-giving. The more life we can get at the least expenditure of effort, the better we like it; decadents and degenerates are in this respect only abnormally nearsighted, looking constantly for bargains in experience, though it shortly kill them. Mere suffering, for example, is an art subject for a decadent; the intensest experience may be had for little effort, but is inevitably followed by a loss of vitality, or by a hardening of the sensibilities, which means enfeebled capacity for life. On the other hand, suffering as a necessary condition of heroism may produce an experience of genuine life. It is less popular than the obviously pleasant only because it requires greater art to make the heroism easily distinguishable as superior to the suffering and because it requires greater intellectual vision to see it. In such art the principle is more subtly used, but it is not ignored.

We may see this most plainly in dramatic paintings. This "Pietà" "left unfinished by Titian was reverently completed by Palma," as Palma himself has inscribed it. It may stand as the type of the beauti-

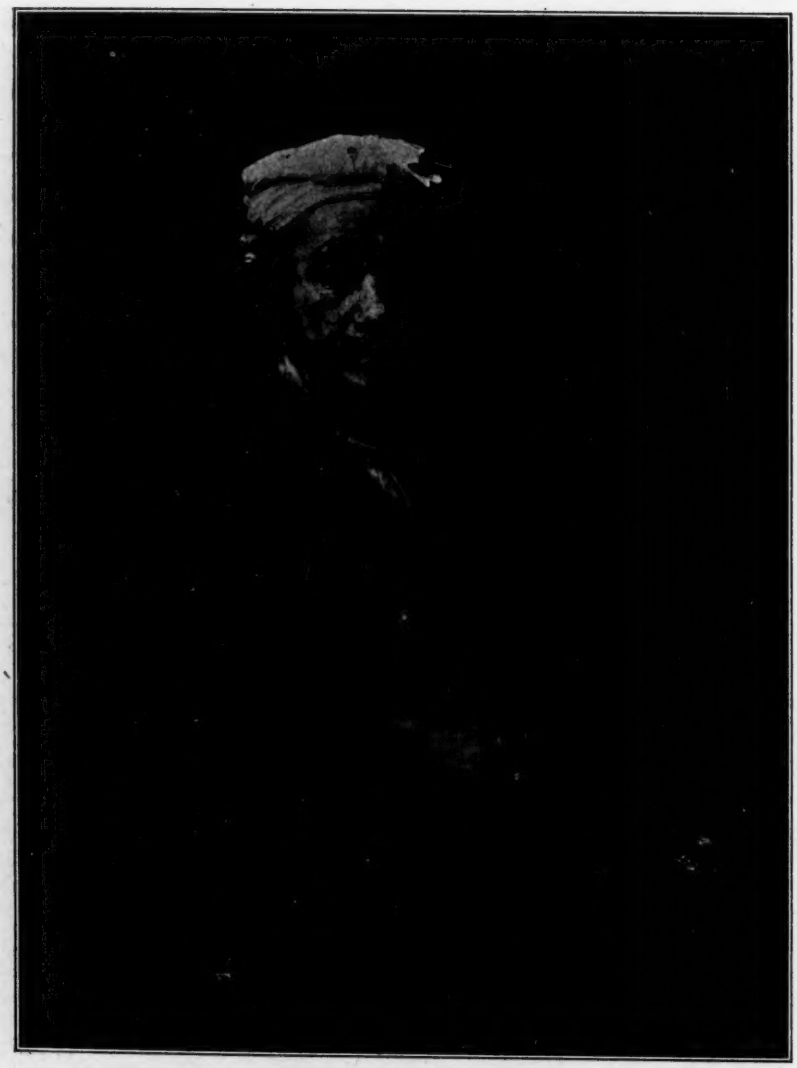
ful in tragedy. In conception it is supreme art, despite the faults of the lesser painter who finished it. The mother of Jesus looks on the body of her son with the deep, calm grief of heroic character; Joseph of Arimathea, a strong man of the formal sect of the Pharisees, is on his knees looking into the face of Jesus with the tenderness of a woman; Mary Magdalene, in uncontrolled passion, brings into relief the self-restraint and power of the Virgin; and the marble statues of the Old and New Dispensations are raised in cold contrast with the human emotions below. We are not simply shown a harrowing incident; we are led into the experience of profound love, impossible to know without this suffering and expressed in monumental power. We feel each character in relation to the others, and the incident itself becomes inseparable from these characters.

In looking on this picture we live much, live deeply and rightly. We see far more than we ever could with our own eyes. We are lifted out of the circle of our habitual thoughts, and experience the deepest emotions that have led mankind from the animal into his high estate.

In great dramatic pictures, closely associated with this principle of constructive emotions there is the element of heightened mental power. The easy grasp of the relations among the persons, and between them



"PIETA," by Titian and Palma the younger. Academy of Fine Arts, Venice.



"PORTRAIT OF THE ARTIST." by Rembrandt. Louvre Museum.

and the incident; the sense of the relations of all the thoughts in the picture—objects, figures, persons, characters, action, with the motives and results of action—built into an indissoluble organism, the infinite complexity of elements forming one great unit of thought, compelling in its clarity—this astonishing intellectual grasp which we have without effort is strongly stimulating. Our capacity is made to abound in renewed strength.

Both of these elements are present in our enjoyment of portraiture—eminently so in this picture of Rembrandt painted by himself when he was an old man. Knowing ones may pay their attention to the manner of the painting, but we laymen must feel that we are face to face with a man whose years have been rich in life.

Yet we have here sure signs of poverty and weakening physical powers. Even if we had read nothing of Rembrandt's life we might guess from this picture that he was poor and had little of the gentleman about him. No one would be better pleased, however, if he were handsome or richly clothed; and this fact is so plain that we must at once accept those unpleasant conditions as a positive factor in creating our enjoyment. These very ills clear away the conventionalities of life and help to show us the real man. The hardships, the struggles, the failures which develop man also reveal him. It would indeed be impossible to conceive of this character apart from its faults—a man led by profound desires athwart every rule of art and society into a vision calm, warm and powerful.

It is not that we learn about this man out of histories of art and then apply our knowledge to the picture, nor is it that we deduce the character from the facts that are told us in the painting; rather, though our interpretation may be indefinite, we feel it—that is, we apprehend it with our whole nervous system. Our eyes rest in quiet contemplation on the eyes of the old philosopher; if we look away, led by the line of the arm to the hands holding palette and brushes, we inevitably look back again at the head—longest and most meditatively at the far-seeing eyes. We seem to take on something of the old man's personality; involuntarily we feel ourselves standing as he is standing, though our actual physical position may not change; we forget, as he forgets, the material conditions of his life; we assume his mood and something of his larger character. Our individual readings of this picture will differ widely, according to our several temperaments and the knowledge and associations of art and life we bring to it; nor can we hope to come to an agreement through any analysis of facial expression. Even if we had a common science by which we could judge of character, Rembrandt had none; he was neither physiognomist nor phrenologist, but as he saw with the inner eye so he painted. This is true of every great painter. To analyze their works gives us no sure interpretation, but to

"CREATION OF THE SUN AND MOON," by Michel Angelo. Ceiling of the Sistine Chapel.

analyze our experience of their works intensifies it and clarifies our vision. So in viewing any portrayal of character it is not our conscious reading of it that is significant; rather it is our subconscious imitation of the character that counts, bringing out some latent quality of our own—some quality which we feel to be good, agreeable because it is life-giving.

Again: in portraiture, great painters give us an insight into essential life beyond that which we ordinarily have. While waiting for a train in a railway station we may spend our time "studying life," but how many of us, with or without great effort, can ever penetrate beneath the thinnest superficialities? Not only are we unpractised; we are bound by the accepted judgments of society, and the most we can do is to pigeonhole the several types. But these great painters present to us a person we have never before seen, and give us an immediate and strong sense of his personality. Even though we disagree about him, we do so rather less than we do about our friends; for in relation to our neighbor our sight is distorted by a hundred influences. Rules of dress, etiquette and morals have blinded us to the eternal man who lives behind and above what we can see of him. Man strives outwardly to appear as his own society would have him, the perfect type of provincial—the New Yorker of 1914, the Parisian of such and such a period, or whatever; while within him is a life at once unique and universal. The illustrator gives us the provincial man. But the great character-painters show us through imperfections and through struggles, a life based on the everlasting instincts of the race and the principles that never change with our mutable standards; through unsymmetrical development and through wreckage, we see supreme man. We put off our blinding limitations and discern clearly.

Where this heightened vision is combined with the emotions which nature has made us to enjoy because they are creative, our experience is one of abounding life.

III. Harmony

Every picture, and indeed every work of art, is like a song in that it consists of words and music—a statement and the sound, or form, through which the idea is conveyed. Half the world listens to the words and is more or less affected in mood by the music; the other half listens to the music and receives the words only as a suggestion to make definite the spirit of the music. It is not an analogy but a translation to say that the sensuous elements of a picture—lines, colors, lights—are visual music.

Michael Angelo's fresco "The Creation of the Sun and Moon" gives us a feeling of overwhelming power. A titanic figure, accompanied by a whirl of cherubim and preceded by a speeding seraph,

represents the creative force of Jehovah. Infinite Deity is not reduced to the figure of a man, but divine power is expressed in transcending harmony of line and movement. The head is great, but it would hardly satisfy us as a symbol of the Creator; the body is super-human, but physical strength can never mean God: the effect on us is rather in the uniting of these elements, and above all, of the lines of the figures and draperies, into a symphonic pattern of crashing harmonies.

Let us see just what this means within ourselves, see how we react to harmony of design. The mechanical process of eye and brain we may leave to the psychologist, but we can recognize a certain sensation which we have before all things we call beautiful. It need not trouble us if we can not agree on a definition of the word "beautiful." We may not be able to bound the town we were brought up in, but we know the look of it. We know that the appearance of a flower, a Persian rug, or a great picture, entirely apart from any meaning or association, produces in us a feeling of pleasure which for the moment drives out of us physical fatigue, desire or any sense of limitation. Beauty of design has been called "supreme order," and harmony, if not the only principle involved, is by far the most important. "The Creation of the Sun and Moon" is an example of such beauty, and an analysis of the picture is helpful.

The sweeping line of the Creator's figure gives the theme of the composition. Around it is a system of repetitions of that theme, in different lengths and positions. The movement through this group and through the seraph is a larger development of the same curve. About the seraph is another system of lines, partial repetitions of the drapery fold from the left foot under the arm and continued over the back. The little folds over the seraph's back are angular, but each discord is repeated in slight variation so that we feel a clear relation between them. The great black line of Jehovah's arms is in discordant contact with the movement of the body, but the shock is a repetition of the crossings of the drapery about the figure, and the line is echoed in certain opposite diagonals. But what of it? Surely esthetic pleasure is not to be had in such dry analysis of line. Certainly not; the analysis is but a slow and painful following of what the eye feels at once,—a simple relationship of many elements. Harmony is an extraordinarily simple relationship of parts, and our experience of it is an unwonted feeling of clear vision.

It might seem at first, then, that two or three squares set side by side would constitute the most perfect harmony. They would do so only in the sense that an octave is the most perfect harmony in music. Such an arrangement would not be extraordinarily simple, but ordinary in the last degree; the eye sees it with habitual recognition. But if those squares should change their proportions so that two of them

should seem to be supporting the central one, we should begin to be interested. As the complexity increases the eye finds exercise; as the simplicity increases the eye finds ease: it is the comparative simplicity of the exercise that is our experience of harmony. When our perception of this simplicity is so effortless as to give us a sense of unused capacity we feel an influx of life which we call an esthetic experience; its cause we call harmony.

We may consider the work of art as a fraction in which the denominator is the number and variety of the elements presented to us, and the numerator is the simplicity of their relationship; the effectiveness varies as the value of the fraction. Of course each of the elements of the harmony must in its turn be considered as a fraction, and so on.

When in place of an influx or life we have from harmony the pleasurable languor of an artificial nervous fatigue, the design will certainly at some time be called decadent. I once went in to the Alhambra in company with a keen-minded physician. For a moment he looked about the sensuously lovely court, and then said, "Dope; that is the explanation of all this. The delight of those old sultans was in the nervous fatigue caused by this infinite, inextricable, beautiful detail. We have the same effect in certain modern music.

"But after all this talk about harmony," says some student of theory, "the effectiveness of this picture by Michael Angelo is caused as much by rhythm." Rhythm is one form of harmony. We find it simplest in a swinging walk or easy run, in which we feel that the left foot treads stronger than the right. A child makes the form clearer by elaboration when he puts in a little shuffling hop after each step, and calls the movement "skipping." Rhythm is no more nor less than harmony between groups of impulses. The principle is the same in the simplest drum-beat and the most elaborate rhythms of Richard Straus, Botticelli, Isadora Duncan, or Shakespeare; the feeling of it communicated to you through your ear, your eye, physical action, or pure thought. The excitement of movement is changed to the stimulation of rhythm by the principle of harmony.

As with rhythm, so with all harmony—it may be expressed in lines, colors, sounds, ideas. Different systems of harmony in these and other realms, are caused by the thought-habits of their authors; and so with the different theories which explain conflicting systems. We have most of us had this difference between senses of order brought home to us. Our books and papers are arranged according to their contents; the maid comes in to clean; when we return we find everything nicely arranged according to size and color. There is some such difference between the classical painter and the impressionist; both are right and neither can hope to enjoy the harmony of the other.

But the design in "The Creation of the Sun and Moon" is not

merely beautiful; it is also strongly expressive. This is so partly because when we are given the right suggestion for our feelings by the subject and by the great physical and spiritual power of the Creator and the rushing host of heaven, our sense of these things and of the mood they suggest is vastly increased by the inrush of life we experience from the harmony. Many a painter has used the same color scheme for a Nativity and a Crucifixion. But in this fresco of Michael Angelo's the lines have a tremendous sweep; we do not merely judge them appropriate; as our eye swings through them, meeting successive shocks from the cross movements, our nervous reaction is similar to that which we have in watching a stormy surf on the rocks. The expressiveness of lines and colors in a picture is in the awakening of physical reaction similar to that accompanying the moods of real life. More; if we accept the modern theory that the feeling of reflex physical reaction constitutes emotion, we must find this method of expression even more direct than that of statement, which has to pass through our intellect before we feel it. The physical causation of emotion is a separate principle from that of harmony, though the two are interactive.

In Nos. I. and II. I have tried to show that the most universal enjoyment of pictures is in the enhancement of life felt in a heightened power of vision when we see any object presented with compelling clarity; that a general element in our experience of narrative pictures is simply an enlargement of this principle to the mental perception of persons and their actions; that a further extension is found in the increased spiritual vision given us in the portrayal of character; and again in the relation of characters and events in dramatic painting. The principle of harmony is based on the same evolutionary fact—the sense of abundant life resulting from enhanced perception. It is a powerful factor in leading mankind beyond the mechanical vision of logic into the unfathomable relations of the universe.

APICULTURE IN THE TIME OF VIRGIL

By GEORGIA WILLIS READ

THE science of apiculture, as it is understood to-day, is the slow growth of centuries of human observation and investigation. For unnumbered ages it has been a work of interest to man to reclaim these singularly untamable insects from the state *feræ naturæ* to that *domitæ naturæ*, as the legal phrase has it—to render their natures sufficiently tractable to enable man to appropriate to himself the benefits of their toil. Though bees have responded to the process of domestication less readily than almost any other of the forms of wild life which man has subjected to his control— since even to-day, after thousands of years of cultivation, they slip back easily and completely into their aboriginal state when opportunity offers—man's efforts to this end have been unremitting, his interest in this task has never flagged. Who knows but that the missing link or an even more remote progenitor sacked the city of the bees for its rich spoil, and handed down to man the instinct for this conquest? Always within the memory of man, at any rate, as the ancient Romans used the phrase, meaning thereby always within the bounds of tradition, honey has been esteemed as a delicacy for the table, and as a valuable condiment in wine-making. The ancient Egyptians, whose very cities have long since crumbled to dust, prized their swarms of bees, which they kept in earthenware vases much as the natives of Africa and Asia do to-day; while it is by no means uncommon to find in histories of ancient races mention of honey as a dainty and a thing of price.

By the time that Virgil wrote his rambling treatise on bees, on their characteristics and their manners, their habits and their needs, apiculture was recognized as an important branch of husbandry. In Virgil's estimation it ranked apparently with the more universal interests of agriculture, the raising of crops and the care of cattle, since of the four books that he wrote on this group of subjects, one is entirely devoted to the culture of bees. In it he gives with patient, painstaking care, a complete guide to practical beekeeping as it was understood in those days, and adds, one can not help thinking for his own pleasure primarily, countless charming apicultural fancies and fables which he had heard. Though the theories as to the life and habits of bees which were held by the most intelligent men of that age, bear no stamp of that absolute and unimpeachable precision which exact science imparts to any subject, one can but marvel at the frequent correctness of their

intuitions and the general propriety of their observations, passing over with uncensorious leniency the startling inaccuracy of certain of their conclusions.

Maeterlinck, in that remarkable life of the bee in which he weaves with threads of purest fact such a marvellous woof of poetry, passes poor Virgil's Georgic by in impatient haste as giving merely the legend of the bee. "All that we can glean therefrom, which indeed is exceedingly little," he says summarily, as he passes on to other fields. Without doubt, his conclusion is just. Virgil sang in an age whose ignorance was vast, whose myths were many, and to one who searches for knowledge from the vantage ground of to-day his poem is barren soil. But to the student of human attainment, of man's gradual triumph in wringing from the natural world the basic truths of science, the result is otherwise.

We are, perhaps, too prone to forget that all knowledge comes to us as a long-accumulated heritage in which we enjoy a life interest, in return for which, should we so desire, we may strive to add some trifle to the principal sum. The world grows in the grace of knowledge, albeit slowly; it moves at a glacier's pace, leaving stranded far behind in the trail of its moraine even those who have been great in their day. As Renan says,

> Descartes would be delighted if he could read some trivial work on natural philosophy and cosmography written in the present day. The fourth form schoolboy of our age is acquainted with truths to know which Archimedes would have laid down his life.

This is true in apiculture, as in any other branch of natural science. As Langstroth, "the father of American apiculture," declares,

> Any intelligent cultivator to-day may, with an observation hive and the use of movable frames, in a single season verify for himself the discoveries which have been made only by the accumulated toil of many observers for more than two thousand years.

To him who, laboring under these advantages, looks backward to learn how much about bees the ancients were able to ascertain from the limited means of investigation at their command, Virgil's work is rich in pleasant surprises and astounding revelations. Without microscopes, which enable us to examine perfectly the minutest organ of the bee, they yet knew that the worker bees were females (as the gender of the pronouns and adjectives which refer to them in Virgil's poem shows us conclusively), and that they never bore any young. Without movable frames, which permit the beekeeper of to-day to examine the interior of the hive at will, they nevertheless had a very clear understanding of the different functions of the bees, and of the social life of the swarm.

If Virgil were to walk through a well-kept apiary of to-day, examining its regular rows of neatly painted, dovetailed hives which take the

place of the "leaky, draughty" basket-work skeps with which he was familiar, he would find cause for amazement. In his time, the bee-keeper carried for his protection in the apiary an ineffective brazier of coals; to-day, when we lift the lid from a hive, we quell the turbulent swarm within by a few puffs from a long-nosed, bellows-fitted smoker. Instead of encountering an irregular mass of unequal, crooked pieces of honeycomb built firmly to the sides and bottom of the skep, and affording no chance whatever for further examination unless cut ruthlessly from their foundations, in which case the flowing honey from the pierced cells would drown many of the swarm, we now find either eight or ten oblong wooden frames, each enclosing a straight sheet of hexagonal-celled honeycomb. Upon the surfaces of these combs the bees live, and in their cells they store the honey and raise the young bees. Thus at a moment's notice, and without in the least disturbing any function of the swarm, we can study the whole economy of the hive, whereas, hampered both by his lack of appliances and by the medieval and impracticable interior of the hive, Virgil must either have suffocated the swarm with acrid fumes in order to subdue it or have drowned it in the flowing honey of the broken combs.

Though he knew much about the life of the swarm, and understood well the different labors into which the toil of the hive is divided, his knowledge was thus of necessity gained largely by inference, without the aid of ocular proof. He might see the sentinels stationed at the entrance of the hive to intercept any robbers or bewildered strangers who might try to enter; he might also see the homecoming bees alighting at the threshold, pausing an instant to balance themselves, then darting into the hive. But he could never follow upon their track, as we can, to see them storing their loads of nectar in the half-filled cells, or placing in the compartments reserved for the purpose the tiny pellets of bright colored pollen, carried home in the little pouches upon their thighs.

Nor could he watch the deeper interests of the hive unfold themselves. The queen, attended by her little retinue of caretakers, goes about the combs performing her one duty of laying her eggs, one in the bottom of each empty cell, the male eggs in the drone cells, the female in the worker cells. One cohort of workers cares for the brood, supplying royal jelly for the nourishment of the embryo queens, if it be the swarming season; and feeding the tiny milky worker and drone grubs which have hatched from the three-day old eggs. Such of these grubs as have reached the proper age are sealed over with a porous capping under which they grow and change form until about the twenty-first day from the laying of the eggs, when the perfect, newborn bees, still gray and fuzzy, chew the waxen coverlets from their cells and traverse with slow, clinging crawl the comb about them. Other workers keep

the hive tidy by carrying out the bits of wax that have dropped to the floor, or line with propolis the slight cracks between the warping boards. Others again seal over such honey as has been properly ripened, while everywhere through the hive are groups of drones, "sitting idle at the banquets of another."

These things he could never see; for him to view the life of the swarm while it was being lived was impossible. He might, by tearing it to pieces, see where and perhaps how it had been, but to do so he must use such violence as to cause a temporary if not a lasting cessation of the functions of the swarm. Yet in spite of the disadvantages under which he labored, a fairly large proportion of the theories which he advances are borne out by the knowledge of to-day. We could, as is only to be expected, set him right about numerous facts in the life of the bee, but of its general habits we could teach him but little, and of its temperament even less.

It is natural, indeed, that his reading of the nature of the bee should more nearly approximate our own, than that his theories as to the facts of its life and the most successful methods of treating it, should tally with those of the present day. For the character of the bee, to all practical purposes, is the same to-day that it has always been; neither new crosses in breeding nor the accumulative gentling effect of centuries of cultivation seems to have modified its disposition, which is to be learned now, as always, by personal observation. The main facts of its life, on the other hand, and consequently the most rational and therefore the most successful methods of treatment, have been very definitely determined by modern scientific investigation.

We know, for instance, as Swammerdam discovered with the aid of his microscope in the seventeenth century, that the "king bee" is not a king, as Virgil believed, but a queen, the only perfect female of the swarm, who gives birth to a constant stream of workers and drones, which keeps the swarm undiminished though the old bees are dying off continually. We know too that the life of the individual bee, far from being "seldom prolonged beyond the seventh summer," as Virgil thought, is often exhausted by hard work during the honey-flow in six or eight weeks, and probably seldom lasts longer, even under favorable circumstances, than six or eight months, the queen being the single exception to this rule. She sometimes lives three or four years, but is seldom sufficiently prolific to keep up the strength of the swarm properly after her second or third year.

Virgil's theory that two colonies often came forth to battle with each other is erroneous; he must have seen two swarms that happened to leave their hives simultaneously and mingled in the air, as not infrequently happens in the height of the swarming season. He may have chanced to see the queens of the two swarms fighting, a by no means

necessary or even usual consequence of this chance coming together. He tells us, too,

> To the old falls the care of the towns,
> And the guarding of the combs, and the fashioning of the cunningly wrought homes.
> The younger ones return wearied late at night,
> Their legs loaded with thyme; they feed on the wild strawberries,
> The blue-gray willows, the cinnamon, the glowing saffron-flower,
> The rich linden-tree, and the iron-colored hyacinth.

Nowadays we know that, broadly speaking, it is just the other way—that the older bees gather the nectar, propolis and pollen, and the younger ones stay within the hive to feed the brood and perform there the other necessary duties. His naïve, yet not unnatural supposition that at nightfall the bees laid themselves to rest in the cells of the honey-comb, whereupon sleep seized their weary frames, we know to be unfounded. Whenever it is too chilly or too windy for them to fly out, they may be seen clustering over the surfaces of the combs, in order to incubate the unhatched brood and to enjoy the comfortable sensation of the animal heat thus generated. Moreover, any one who is familiar with the interior of the hive knows that in summer every cell in every comb is needed in a fairly strong colony for storing the incoming harvest and for raising the young bees, while during the height of the honey-flow it is questionable whether the bees can be said to sleep at all. Many beekeepers believe that unless the nights are so cold as to chill them, they work unceasingly from dusk to dawn, as well as from dawn to dusk, during this brief period.

We can see, by the brighter light of modern knowledge, how Virgil was wrong in these and in many smaller particulars, how he incorporated into his work the errors that were prevalent in his day, and endorsed the methods then in vogue, superstitious and unavailing as they too often were. But if he sometimes went astray as to his facts, traveling, as he did, over a country with but few landmarks to guide him, he retrieved himself in other fields. We approach the bees armed with facts that explain their habits and throw light upon their moods, but he was forced to solve his problem just the other way. He must observe their disposition and their ways, and then deduce his facts as best he could. It follows as a matter of course that he should speak more wisely of the things that he saw for himself than of those that he knew only by inference.

The somewhat unusual habits of the bees he read with remarkable insight. But what he understood best of all about these strange little insects, perhaps because in contemplating them he brought to bear upon them the subtle comprehension that is born of sympathy, was their character, their temperament. In this respect he speaks as a master,

and as one whose teaching the shadow of years has not tarnished. Here his perceptions winged themselves to their goal as swiftly and as unerringly as the eager bees themselves fly to the hive with each load of nectar when every hour of the summer's day warns them that the golden harvest time is fleeting. He knew that work made the bees cheerful, and that sunny weather cheered their hearts; that discouragement did but make them work the harder, and that death itself, dreaded instinctively by every animate thing, was to them, when set against the common welfare, a thing of naught.

Half playfully, half affectionately, yet wholly respectfully withal, he continually likens the race of bees to the race of men.

> I will tell you of sights of tiny things to be wondered at,
> Great-hearted leaders, the customs of the whole race,
> Their passions, tribes, and battles,

he says in his opening paragraph. In the course of his pages, "grandsires of grandsires are numbered," "the hearts of the bees are agitated in war," "the kings turn to the foe great souls in tiny breasts," "sad funeral rites are conducted." Often in the course of the poem he refers to their homes, their dwellings, their waxed realms and rich storehouses, their palaces and cities—a picturesque phraseology which Maeterlinck repeats with great effect.

"Behold," says Virgil, giving us in one long paragraph a far from uncreditable résumé of the life and labors of the bee,

> Behold, I will now describe the natural traits
> Which Jupiter himself has given to the bees as a reward
> For their harmonious humming . . .
> When they fed the king of the sky in the Dictean cave.
> They alone have a common offspring, a common building of the city,
> And spend their lives under powerful laws.
> They alone know their country and their settled home;
> Mindful of the coming winter, they endure toil in summer,
> And put aside for the common advantage what they have gained.
> Some direct their attention toward the provisions,
> And by agreement labor in the fields;
> Others within the home place the nectar of narcissus
> And the sticky sap from bark for the foundation of the comb,
> And thence draw downward the tenacious wax;
> Others raise to maturity the young, the hope of the race;
> Others ripen the honey, and fill the cells with nectar;
> To some has fallen by lot the guardianship at the gates. . . .
> The work seethes, and the sweet-smelling honey is fragrant with thyme. . . .
> An inborn love of harvesting urges on the Cecropian bee,
> Each in his own function. . . .
> There is one time of toil, one rest from work, for all.
> In the morning they rush out from the gates; there is no delay;
> Again when evening has warned them to cease
> From feeding in the fields, they seek their dwellings,

They refresh themselves; a humming sound arises,
They sing about the entrances and the thresholds. . . .
Nor do they retire very far from the hive when rain threatens,
Nor trust to the sky when the east winds begin to blow,
But all around under the walls of the city,
They safely fetch water and venture upon short expeditions. . . .
You will wonder indeed at this custom of the bees,
That they do not idly relax their bodies in love,
Or bring forth offspring with labor;
Instead they gathered their sons
From the leaves and the fragrant herbs,
They themselves supply a king and little subjects
And refashion their palaces and waxen realms.
Often, too, in wandering over the rough, flinty rocks
They have worn away their wings,
And voluntarily given up their lives under their burden.
Such is their love of flowers and their glory in making honey!
Therefore, though the limit of brief life overtakes them,
Yet the race remains immortal,
And the fortune of the home endures through many years. . . .
Furthermore, not Egypt, nor great Lydia, nor the people of the Parthians,
Nor even the Median Hydaspes, so honor their king.
While he is unharmed, all are of one mind;
If he is lost, they break their faith. . . .
They surround him with incessant hummings, and attend him
In great numbers, and expose their bodies in war,
Seeking a beautiful death through their wounds.

(It is true that bees have this feeling for the queen, understanding that without her there is no hope for the future prosperity, or even existence, of the swarm.) From these signs, Virgil says in conclusion, some have maintained that the bee has a part of the divine intelligence and that it too, in common with flocks, herds, men, and all the race of beasts, has drawn in at birth its tiny vital spark from the god that penetrates the earth and the sea and the profound skies—"esse apibus partem divinæ mentis et haustus ætherios."

Again he tells:

The more they are exhausted, the more zealously all will set about
To repair the ruin of the fallen family
To fill the cells and to build storehouses for the honey,

as indeed they will. He also says, when speaking of an old Corycian who made a paradise for himself out of a few waste acres by setting out flowers and fruits and esculent plants to grow among the brambles,

He therefore was the first to abound in prolific bees and numerous swarms,
And to force the foaming honey from the pressed combs.
He had linden-trees and many pine trees;
With just so many blossoms as each tree
Was decked in in the spring,
Just so many ripe fruits it held in autumn.

It does not seem to be forcing the meaning of this passage to infer from it that Virgil had some knowledge of the valuable services of bees in fertilizing plants of all kinds.

To have learned all that he tells us about bees, Virgil must have mastered the subject of apiculture as it was understood in his time. That he gained his information at first hand, or at least verified it by personal observation, seems indubitable. For here and there all through his work are convincing bits of description, sometimes merely felicitous phrases, that recall the life of the hive forcibly to any one familiar with it. He says:

> As for what is left when the golden sun has put winter to flight
> Beneath the earth, and has revealed the sky with summer light,
> Immediately they (the bees) wander over all the glades and forests,
> And rifle the bright-hued flowers, and lightly-moving,
> Drink from the surfaces of the streams.
> From this time, joyful from I know not what delight,
> They cherish their family and their home,
> And make the ripened honey.

This could not fail to paint vividly for any beekeeper the yearly awakening of the bees, when, shaking off the torpor of winter, they prepare with eagerness for the advent of summer, that fraction of the year in which alone they lead a full and active life. His description of the listlessness and apathy of bees which are diseased at once suggests the appearance of a colony which is suffering from the ravages of bacillus alvei, or foul brood, the terrible, almost pestilential malady of the apiary. He says:

> But indeed life has brought our misfortunes to the bees;
> If their bodies shall droop with a sad disease: . . .
> The sick are of a different color;
> A dreadful leanness marks their appearance;
> They carry forth from the dwellings those bereft of life,
> And conduct sad funeral rites;
> Or clinging together by the feet, hang at the thresholds,
> Or delay within their house, and are listless with hunger
> And inactive from the cold which they have caught.

Again he says, when speaking of the life of the bees during the harvest season, "the work seethes, and the sweet-smelling honey is fragrant with thyme." The work does seethe; his phrase exactly describes the abnormal, all-pervading activity of the swarm during the honey-flow. Often at that time we can tell by the delicate aroma, one might almost say the bouquet, of the honey, from what kind of flowers it is being made. To-day only that of the mountain sage resembles in fragrance and flavor the honey of the ancients which was made from thyme, of which the fabled honey of Hymettus was the finest type.

Interspersed throughout Virgil's discourse are numerous precepts

for the guidance of the apiculturist, some of them still as sound as can be devised, others again being incomplete or obsolete. He knew that certain things conduced to the prosperity of the bees, and therefore to the profit of the owner. The requisite points of a suitable situation for an apiary, a highly important factor in successful beekeeping, he covers very well. A dry, well-drained slope, shelter from the wind, pools of flowing water, water being essential in raising the brood, and protection from the heat of the sun, were necessities upon which he insisted. "Do not trust them to a deep swamp," he cautioned his disciples, "nor where the hollow rocks resound when struck, and the echo of the voice rebounds."

> Let there be flowing fountains and pools bright with moss,
> So that when the new kings lead out the swarms
> And the young bees, released from the honey-combs, sport about,
> The neighboring bank may invite them to withdraw from the heat,
> And the tree in their way shelter them with its leafy hospitality.
> Across the center of the stream, whether it pauses here or flows swiftly,
> Place willows athwart, and lay in large rocks,
> That they may alight on frequent bridges,
> And open their wings to the summer sun,
> If perchance the east wind has scattered the laggards
> Or plunged them headlong into the stream.

He mentions also the need of having plenty of pasturage, though this he proposes to provide by setting out suitable plants and shrubs:

> Let him who makes such things his care bring thyme and pine trees
> From the lofty mountains, and plant them far and wide about the dwellings;
> Let him bruise his hands with hard toil; let him set out these shrubs
> And irrigate them with friendly showers—

while to-day, when bees are kept in any numbers, a location must be chosen near great fields of some honey-yielding plant, such as clover or buckwheat.

He appeared to know that with bees, as with every other form of life, the breed must be kept up from the best stock;

> But when you have recalled both leaders (kings) from the battle,
> Give to death him who seems inferior, lest he be a hindrance;
> Permit the better one to reign in the empty halls.
> For there are two kinds; the one shining with scales of gold,
> Distinguished both by his shape and by his ruddy, golden hue.
> The other is terrible with sloth.
> As the figures of the two kings, so are the bodies of their peoples.
> For the one kind is horribly ugly; . . . while the others
> Shine and glitter, aglow with gold,
> And their bodies are marked with even bands.
> This is the better breed; from this source at the proper season
> You may extract the dulcet honey from the combs.

To-day, after a lapse of nearly two thousand years, the Italian breed

remains distinct, its special characteristic being its superiority over all other breeds in gathering honey; the particular marking of its best strain is still the glistening, golden color of the three largest of the rings of horny substance that encase the body of the bee. Even now we know no better rule to follow in requeening an apiary than to select for the purpose the offspring of the most beautiful and the most efficient queens at our command.

Again he tells us:

> When the inconstant swarms fly about and sport in the air,
> Condemn their hives, and leave their cold dwellings,
> You should restrain their unsettled minds from this vain play.
> Nor is it a great task to control them;
> Remove the wings of the king; while he remains behind
> None of the bees will dare to follow the path through the air,
> Or to tear up the standard from the camp.

In the spring bees are sometimes guilty of this "vain play," or swarming out, as it is called now-a-days, when feeling that summer is unduly delayed and that their store of honey has dwindled distressingly, they leave their hive, only to die of hunger or cold unless rescued by the apiarist. The point of interest here, however, is that one of the most approved of the modern methods of controlling the swarming impulse of the bees, is to clip the wings of the queen on one side, thus preventing her from flying away with the swarm and so necessitating its return to the hive, since, as Virgil knew, the bees will not desert the queen. Though he understood this principle which has become so important in the treatment of swarming, his method of making a swarm settle is, oddly enough, obsolete. We no longer beat the cymbals, as he directed, or sprinkle bruised herbs upon the ground to cause the bees to cluster and alight.

In view of the fact that artificial feeding is a very important factor in modern beekeeping, it is interesting to note that Virgil speaks of this process. Now-a-days the intelligent beekeeper feeds his bees not only to keep them from starving in case their stores run low; he also supplies them with trays of sugar syrup in the spring to stimulate them to raise broods sooner than they would otherwise do, so that they may be ready in large numbers to gather the harvest as soon as it comes. Virgil suggested to his followers that they should introduce honey into the hives by means of hollow reeds.

He understood remarkably well, in the main, what was necessary for the comfort and tranquillity of the bees. He knew that they needed constant sunshine to keep in a healthy condition, and that it was but poor economy to stint their food supply by taking too much honey from the hive. He thought that their homes should be kept in such neat and tidy shape as would make it easiest for them to protect themselves from

their enemies. "Who will hesitate," he asks, "to fumigate with thyme and to cut away the empty comb?" He gives, in two divisions, a list of those apicultural pests whose depredations the beekeeper should try to prevent, or at least to control. Among the minor dangers that threaten bees in the form of insects or small animals that have a taste for honey or that eat the bees themselves, he mentions swallows, bee-martins, newts, lizards, hornets, and spiders. When one considers the number of bees in a single colony, however,—upwards of ten thousand in the winter and several times as many in the summer—one can easily see that the combined losses from these sources are insignificant.

He mentions also the bee-moth, "shunning the light;" an accurate description, since its custom is to remain hidden during the day. It does not attempt to enter the hive until dusk, when the bees can not see to attack it. This moth is a really dangerous enemy, being able to harass seriously a strong colony, and often to destroy entirely one that has lost its queen. As Langstroth says of it:

> The bee-moth has for thousands of years supported itself on the labors of the bee, and there is no reason to suppose that it will ever become exterminated.

It is rather curious that Virgil nowhere makes any mention of the bee-louse, which, to-day at least, is a source of considerable trouble to the beekeepers of Italy, although in this country it is almost unknown.

His description of that disease of the bees already referred to—so serious a scourge as to make it one of the chief dangers that threaten them—completes his list. For there is very little reason to doubt that this disease of which he speaks is the same as that now known as foul brood, or else closely analogous to it. This is a highly contagious disease, attacking first the brood, which decays instead of hatching; the bees also become infected, and presently die. This malady was doubtless known to apiculturists as long ago as Virgil's time; Aristotle, in his "History of Animals," describes it briefly but in no doubtful terms. Even to-day it is a justly dreaded enemy to apicultural prosperity. It is scarcely to be wondered at that, when we have not yet devised a very satisfactory method of dealing with it, Virgil's remedies should be of no avail. To stamp it out, its spores and bacilli must be destroyed by fire or some other equally efficient agent. His directions as to the various herbs steeped in liquids, and the roots boiled in wine, which were to be fed to the bees to cure this fell disease, were worthless. This treatment, like certain precautions that he advises taking for the welfare of the bees, such as being careful to cut down all the yew-trees near the bee-yard, and never to burn red crabs in the fire, could not have been of the slightest use save perchance to afford to the zealous beekeeper of those times, who conscientiously followed these instructions, the salutary sensations that follow duty done.

Unwittingly he sometimes directed his disciples wrong; yet he labored faithfully in their service, nursing his didactic impulse carefully until he had given them, as well as he was able, an insight into the life of their pets. This store of sterner precepts conscientionsly discharged, he turns most willingly to those of mythological suggestion, proceeding to tell his followers how to restock their apiaries, should they chance to lose all their bees. He gives as a practical measure to be followed, yet naming it a tradition withal, the old, old myth of bees springing from dead cattle, "how the tainted life-blood of a dead bullock has often borne bees;"—the same old riddle, "out of the strong came forth sweetness, and out of the eater came forth meat." Virgil says of it:

First a place small and sheltered for this very purpose is chosen;
This they enclose with a low roof of tiles and with walls,
And they add four windows of slanting light toward the four winds.
Then they seek a two-year old bullock, whose horns are just beginning to curve.
His nostrils and his mouth are covered over
Though he struggles greatly, and after he has been slain by blows,
The battered entrails are crushed within the unbroken skin.
Thus they leave him, laid in the enclosure,
And they place under his sides branches of thyme and fresh wild cinnamon.
This is done as soon as the driving zephyrs roughen the waves,
Before the meadows brighten with new colors,
Before the chattering swallow hangs her nest from the beams.
Meanwhile the liquid, warmed in the young frame, heats
And animals of a wonderful kind are to be seen,
Lacking in feet at first, but soon whirring with wings;
They mingle, and more and more take to the thin air,
Until they have burst forth as a storm poured from summer clouds,
Or as arrows from the vibrating bowstring,
When the swift Parthians first begin to fight.

Thereupon he drops easily and contentedly into that vein of poetry that comes so gracefully from him, stringing upon a slender connecting thread the story of the loss and the recovery of Aristæus the shepherd's bees, into which he introduces the whole tale of Orpheus and Eurydice. With him, we accompany Aristæus on his pilgrimage for aid to his mother, a water-nymph, who sits spinning with her maidens of euphonious names, Drymo and Phyllodoce, Clio and Lycorias, Xantho and Beroe, in their translucent, glass-colored chamber in the depths of the sea, while one of their number recounts the "numerous lovers of the gods, from Chaos down." In his company we follow the fortunes of Aristæus to their happy conclusion, when, having obeyed the oracle, he is rewarded by seeing clouds of bees come forth on the ninth day from the bullocks that he has slain, and cluster at the top of a tree, ready to be hived.

Filled the marvelous charm of his closing pages, it is with an effort that we turn to consider the value of his discourse. It is a very capti-

vating field over which he has taken us; apiculture in his time was a picturesque occupation, even when seriously pursued. His picture of it is pleasing, not only as a thing beautiful in itself, but also as affording an interesting contrast to the apiculture of to-day, as enabling us to measure our present growth by an ancient scale. Practical beekeeping is indeed far different now from what it was in those days; apiculture at present shows many new features, and lacks many that distinguished it then. Yet in one respect it remains the same, and, I venture to think, will always do so; that is, in the enthusiasm of the bee-keeper for his bees. Even as Aristæus, we to-day are grateful for our teeming hivefuls With Virgil we cry,

> **Averter of thieves and birds, protect them.**
> **Let gardens breathing with saffron flowers allure them,**
> **Let the guardianship of Hellespontaic Priapus, with his willow scythe,**

AVAILABLE FOOD SUPPLIES

By Professor J. F. LYMAN
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THE food problem is distinctly a modern one in the United States. Two generations ago no such problem was clearly recognized. Fish were plentiful; pigeons, deer, wild turkeys, water-fowl, quail and buffalo were abundant; wild berries, fruits and nuts could be obtained easily and in large quantities. Naturally food was cheap and there was enough for all, and of a kind sufficiently varied to suit the taste of any. All this has changed. Game animals have practically disappeared. Wild berries, fruits and nuts are no longer of importance in our dietaries. We have seen our population increase at the rate of over twenty per cent. every ten years until the increase in production of food products no longer keeps pace, but lags far behind, and we realize that there is such a thing as a food problem.

If the present rate of increase continues, the population of the United States will approximate five hundred million at the end of the present century. Is it possible to feed that number of persons on the products of our three million square miles? China and India both support a population as dense; but both of these countries are distinctly agricultural. The mass of people live on the land and are engaged in producing food. In this country the great increase in population is in the cities; while the food-producing class is increasing comparatively slowly. The reports on agricultural products exported from the United States illuminate the food problem in an instructive way. If we compare the exports in 1912 with those for 1900, we find that the amount of cheese shipped abroad declined 85 per cent. in that period, beef products declined 65 per cent., pork products declined 30 per cent., corn declined 80 per cent., wheat declined 57 per cent. What do these figures tell? Simply that we have needed the food at home to supply our increasing millions and hence had less to sell in the markets of the world. Can we continue to feed our people by reducing the exports in food stuffs? Obviously not, and in many instances they have been reduced already near the vanishing point. We have even actually begun to import meat and corn. It is significant also that free government land suitable for agricultural purposes is no longer available; hence we can not look for relief by bringing under the plow large tracts of virgin soil.

Is there likely, then, to be a scarcity of food in this country in the near future? No, there is and will be plenty of food, but some changes

in dietaries undoubtedly will have to be made. Let us notice. In 1910 for every man, woman and child in the United States there was produced seven bushels of wheat, thirty-two bushels of corn, four bushels of potatoes, and forty pounds of sugar. There were six tenths cattle for each person, six tenths sheep, and seven tenths swine. Add to this the fruits, vegetables, poultry and dairy products, oats, and other small grains and we see that there is plenty of food to go around and to spare.

There was grown in the United States in 1912 corn, which if assembled in one immense field might have covered Germany or France entirely with its rustling phalanx. How many millions might be nourished by the produce of this tremendous acreage! Here is a great source of human food at present utilized in a very slight degree.

Man takes food first of all that pleases the palate. We can no longer make our choices on the basis of palatability alone, and a study of the principles of nutrition must be pursued to help us out of those difficulties which arise from a restricted supply of food. Food has two primary functions in the body; first, to supply material out of which the body is built; and, second, to furnish energy to warm the body and to drive its machinery. Perhaps the second function is the more important. Plants alone have the power to collect solar energy and store it up in a latent or dormant form in their seeds and other parts. Animals may, by eating and digesting these plant materials, liberate and utilize this stored-up energy. When corn is fed to a steer under favorable conditions three per cent. of the energy of the corn may be recovered as meat in the edible portion of the carcass. The remaining ninety seven per cent. was used by the animal in its various activities and lost as far as the nutrition of man is concerned. In pork the recovered portion amounts to sixteen per cent.; and with the dairy cow eighteen per cent. of the energy of the food is found in the milk produced. Obviously this is a wasteful process, this conversion of grain into meat and milk. It has its justification only in the greater palatability and digestibility of the final products. Doctor Armsby, of the Pennsylvania Experiment Station, draws the conclusion: "all the edible products which the farmer's acres can yield will be needed for human consumption and the function of the stock-feeder in a permanent system of agriculture will be to utilize those inedible products in which so large a share of the solar energy is held and to render at least a portion of the latter available for human use."

But shall we solve our food problem as it has been handled in some densely populated countries such as India and China? With an area nearly twice that of either of these countries, the capacity of the United States to maintain a population on the same standard as obtains in China, for instance, would be perhaps relatively as great. It would mean a great change in our standard of living, one to which we should not take kindly, and one which we hope need never be adopted in this country.

What would the liberty-loving American think had he to subsist on the restricted fare of the Chinaman as described by Mr. Chester Holcombe in "The Real Chinaman."

> Their daily food consists of rice steamed, cabbage boiled in an unnecessarily large amount of water, and, for a relish, a few bits of raw turnip, pickled in a strong brine. When disposed to be very extravagant and reckless of expense, they buy a cash worth of dried watermelon seeds, and munch them as dessert. . . . The description answers with entire accuracy for the food consumption of the great masses of the Chinese people—not for the beggars or the very poor, but for the common classes of industrious workingmen and their families, whether in the great cities or in the rural districts. . . . The only luxuries of which they dream are an ounce or two of meat at very rare intervals with their invariable food of rice and cabbage, and the necessary tea and tobacco.

Or would the fare of India please better? Colonel Sir Thomas H. Holditch tells us:

> Probably three fourths of the entire population live on the grain of the millets, or various kinds of pulse. In lower Bengal, and in parts of Madras and Bombay, in Burma and Ceylon, rice is the staple food of the people, . . . elsewhere it is reserved for the consumption of the wealthy.

Even in Greece the food supply is much restricted, for we read in the Consular Report on Industrial Conditions by Horton, 1908:

> At night the family dines on a few cents worth of rice, boiled together with wild greens and olive oil, and bread, or wild greens boiled in olive oil and eaten with bread or some similar inexpensive dish. Meat is eaten by the laboring classes as a general thing three times a year, Christmas, Easter and on the so-called "Birth of the Virgin." Such a family as I am describing, the average laboring man's family of Greece, rarely if ever see such things as butter, eggs and milk.

The corn crop alone of the United States in 1912 was sufficient to supply nourishment for two hundred and thirty million people living on the standard maintained by the working class in China, India and some other countries. The American, however, in general has never appeared to relish corn as a direct article of food. A prejudice has prevailed that corn was unfit for human food and useful only in the barn and stable for their less discriminating occupants. The reports of government experts to the effect that corn is as digestible and nutritious as wheat have apparently made few converts to the greater use of corn. But we shall learn to eat more corn, not because we are told of its nourishing qualities, but because it will be prepared in an attractive form and because it will be cheap.

Machinery has been perfected for the milling of wheat so that the digestible portions are separated from the indigestible and a superior human food prepared. Wheat flour stands supreme among the cereal flours and it is likely to maintain this position, still it is undoubtedly in the development of industrial processes that we shall find the solution

of the problem of economically converting corn and similar products into human food which will be palatable and nourishing. A good beginning has already been made in the manufacture of starch and glucose as well as breakfast flakes from corn. These and similar industries are bound to grow rapidly. Nor is corn the only material which might be appropriated directly as human food and which is used at present little or not at all for that purpose. Oats, barley, rye, soy beans and peanuts and various by-products such as cottonseed and linseed cake might be utilized more largely. Modern science will very likely devise methods for extracting the valuable constituents from these products in such a way that they will be available for human food in an attractive form and nourish man in a state of highest efficiency. Some progress has already been made along this line, but it is barely a beginning.

Does this mean that we shall all in time turn vegetarian? No, there will always be food for domestic animals and meat and dairy and poultry products will always be important items of human diet. The grasses, clovers, straws, stovers, and certain by-products of the refining processes of seeds, etc., will always be directly unavailable as food for man and can probably best be utilized by converting them into animal products of various kinds. The amount of meat consumed, doubtless, will decline and a reduction in this respect may take place without danger and without detriment to the race.

Long ago Daniel, the prophet, and his companions demonstrated the virtue of a simple vegetable diet when they refused to eat the king's meat and wine, provided for the boys of the court, and chose rather pulse and water. At the end of the training period, when the boys were examined, the faces of the Hebrew children were found to be plumper and their minds more alert and keen than those of their companions who had dined more sumptuously, but who had, perhaps, studied less diligently.

The study of human nutrition has not yet produced a simple formula for man's guidance in the selection of his food. Such formulæ have been successfully used in the feeding of rats, and the skillful stockman in his feeding operations carefully follows charts and rules provided him by experts on animal nutrition. We may expect that similar rules will obtain more and more in human nutrition and there will be, some time in the future, such a thing as scientific feeding of men.

THE SMALL COLLEGE AND ITS FACULTY

By ONE OF THE PRESIDENTS

THIS president has been reading an article in the POPULAR SCIENCE MONTHLY for May entitled "The Small College and Its President"—hence these words.

Probably it is rarely the case, when a number of alumni, each more than fifty years of age, foregather and begin to talk over old times, that some one doesn't tell the story of the time he and others put a cow in the college chapel. These stories can not all be true—there haven't been cows enough. Probably they are more or less fictitious variants of some fundamental cow-myth which originated under those vague conditions commonly described as "mists of antiquity." In a similar way it may fairly be questioned whether the awful condition described in the article to which allusion has been made really exists in concrete form and precisely as set forth in any particular institution.

If there is a college such as is described in this May article it should certainly be abolished at once. It is a disgrace to the whole system of education in America. It is very difficult to believe that, because of their athletic prowess, athletes are given marks higher than they deserve. It is difficult to believe that the sons of wealthy patrons are unfairly marked in the professors' classbooks and on the registrar's records. Whatever trustees and faculties might think, no body of normal undergraduates would stand for any such treatment of that larger part of their number neither athletic nor rich.

But the object of this writing is to describe briefly another small college which is believed to be more nearly like the typical American small college. It is something less than one hundred years old. Its undergraduate body numbers perhaps less than three hundred. It is governed by a rather large board of trustees. All but two of them are college graduates, and most of them are graduates of the college over which they now preside. It includes clergymen, lawyers or judges, and business men—bankers, insurance men, manufacturers, merchants—in proportion as the numbers 10, 16 and 20. It is under no ecclesiastical control. The president of the college is *ex-officio* president of this board of trustees. His powers are nowhere stated or defined in the charter or statutes of the college. It takes a two-thirds vote of the trustees to dismiss him, and he is *ex officio* a member of various committees. He has two votes in the faculty if he cares to use them—one regularly and

another in the case of a tie. To the faculty, which consists of all the permanent officers of instruction, is, by the statutes, "committed the government of the students." This term "government" is considered to include both the disciplinary and the instructional functions of the college officers.

The courses of study, prepared originally by the faculty, are prescribed by the supreme governing body and changes are from time to time made by the faculty under the authority of the trustees. Within ten years at least there has been no case in which the wishes of the faculty in these matters have been overruled by the trustees.

It is probably true that the president has a good deal of practical authority. It is based upon nothing except the feeling of the faculty that as the president is in a peculiarly responsible position both to the trustees and to the public, because his view is necessarily wider and more comprehensive than that of the professors through his relation to the public, because there are after all other considerations than those of any particular classroom which must affect the college policies—for these and other reasons his wishes are entitled to some weight. The president has no veto over the action of the faculty. For many years there was a provision giving him this authority. It was repealed at the request of an earlier president, and the present president refused to have it restored when some of the trustees were rather disposed to restore it.

As for the unhappy athletes in this small college it is unquestionably true that they get less consideration than anybody else. Any excuse asked by an athlete, or request for special consideration, any explanation of failure or misconduct offered by such a person is regarded with peculiar suspicion—almost enough to justify the statement in a very amusing book of college stories that "a college professor always hates a man who weighs over one hundred and seventy-five pounds."

Similarly, it is unthinkable that this faculty should modify a student's marks according to the social or financial prominence of his family. One of the most excruciating and most frequent tasks of the president is to write letters to his personal friends and to wealthy patrons of the college explaining that their sons have been dropped on account of deficiency in scholarship. It is not a pleasant job and the performance of it goes far to justify the somewhat larger salary which the president receives. Indeed, quite antithetically to the situation in the college described last May, it is the president who has to take most of the "knocks" arising from the actions of the governing body of the college, the faculty, whether or not he happens to be personally in sympathy with all that is done. Again and again has he found himself obliged to defend acts and policies with which he was by no means in accord.

At present there seems to be a good deal of unrest among college professors. It is a little difficult to see why; for, after all, the president and the professors alike are hired men engaged for a consideration to discharge fairly definite duties. It is difficult to see why a college professor should make so much more fuss about losing his position than is commonly made by an officer in a bank or an insurance company or a corporation or in the public service. The college professor is not necessarily an expert in education or in college administration as carried on in these later days. He is apt to be a specialist, knowing something, indeed, of many subjects and a great deal about some restricted range of intellectual activity. Often he is absolutely without qualification for formulating a course of study suitable for the average boy, for advising the average student as to the studies that are best for him, or for the construction of any educational policy whatever.

The fact that A is one of the highest living authorities on clam shells needs to be supplemented by other facts before this man can expect much importance to be given to his views on the training of youth or concerning the apportionment of funds among a dozen or fifteen different departments. In most faculties, however, there are men not disqualified by personal disposition or training for work other than that in their own specialty. It is the policy of our faculty to utilize the qualifications of these men by distributing them as chairmen of active committees to which are referred questions of discipline, choice of electives, and similar important matters.

Probably we might do well to think twice about the importance to the professor or to the college of much of that which is called research work. A man can not teach well if he stops learning. Undoubtedly it is much pleasanter to work in the library or in the laboratory, and much pleasanter to work in one's own study, than it is to try to convey information to a body of rather careless young men who would prefer not to be instructed. But, after all, in the small college at least, the instruction of youth is the principal object of the professor's connection with the institution. There are not many professors whose research work is of any value whatever except to themselves. Those who are competent to enlarge the boundaries of human knowledge constitute a different class and are few in number. Such should have every opportunity and every facility. Generally these men are such wretchedly poor teachers that they have no place in the college faculty. Their service to mankind must be rendered elsewhere and under different conditions. Of course the college professor must have opportunity and time for continuous self-improvement, but he mustn't be allowed to forget that his job is that of a teacher.

It is questionable also whether the faculty should have too much to say about its own membership. In our college, the president, when

an appointment is to be made, confers freely and with entire candor with the professors whose work is most like that which is to be done by the new incumbent, and some decision is generally arrived at by a sort of mutual understanding arising without formal rules. Nevertheless it has happened again and again that appointments must be made under conditions absolutely precluding any considerable conference with members of the faculty. It is probably true that professors have means of finding out things about candidates from other institutions which lie beyond the range of the president's powers of investigation; but there is one difficulty about the circumstances brought to light by professors investigating each other. A good deal of the information thus collected is not true. It is based upon personal jealousies, pique, personal likes and dislikes—all of which give a certain pleasant tang to life in the college faculty but which are very misleading when allowed to count for much in judging the man who is leaving one faculty for another.

We are hearing a good deal just now of that freedom of thought and of the expression of it which ought to be enjoyed by college professors. Evidently college professors must be allowed to think without restraint within very broad limits. The expression of their thoughts should not be criticized or at least should not be used as a reason for dismissal from college because some trustee happens to disagree with them. Nevertheless, it must not be forgotten that even college professors sometimes talk very foolishly, and if a professor or a president makes himself and the institution which he represents ridiculous there would seem no very great injustice in suppressing him. Isn't it a possibility that college men are all too thin-skinned, too sensitive, too jealous of each other, too considerate of the persons whom they think themselves to be.

Various recent developments seem to indicate a regrettable tendency on the part of college professors toward something like class feeling; toward the notion that they are somehow different from other people. It will be a great misfortune if this idea is allowed to prevail, if it is allowed to become permanent. When we forget that everybody is pretty much like everybody else, when any persons employed in a particular fashion get to think that they are otherwise than just folks, there is trouble brewing. This president feels pretty sure that the average college professor is too sensible to allow himself to be betrayed for long into such an untenable position.

Within the last ten years there have been in this small college of ours thirty-seven men who have held permanent appointments as well as a good many who have taken a small amount of work in emergencies or who have been here temporarily while professors have been away on leave of absence. Of these thirty-seven twenty are now in the faculty. Of the seventeen who have left three were dismissed either for ineffi-

ciency in teaching or for the exhibition of grave defects of character. In each case there was substantial unanimity on the part of trustees and faculty. Two of the seventeen have retired on their pensions. One withdrew on account of a breakdown in his health, eleven resigned, to our great regret, to accept considerably more lucrative positions elsewhere. We rejoiced in this evidence of their distinction and tried to fill their places with men equally good. Some of these we shall probably lose by and by in the same way.

On the whole, isn't this a pretty good small college? There have been evidences of weakness in discipline in years past, due in each case to the mistaken leniency of the faculty. This has never been due to outside pressure. One can't help wondering whether this small college which was discussed last May is not suffering more from morbid and unfounded fears on the part of the professors than from any real danger of autocratic action by president or trustees.

THE GEOGRAPHICAL DISTRIBUTION OF AMERICAN GENIUS

By Dr. SCOTT NEARING

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THE last few years have witnessed a friendly controversy between the champions of nature and the champions of nurture, over the forces that are responsible for greatness. The nature advocates have insisted upon the importance of heredity in shaping men's lives. The nurture advocates have laid equal emphasis upon environment. Each of these groups has relied upon New England as one proof of the contention.

Both parties to the controversy are willing to admit that New England has produced a considerable proportion of the great men of America. Those scientists who throw emphasis on the importance of heredity hold that New England, having made a contribution to the number of distinguished men in the United States wholly out of proportion to its population, stands as a substantial proof of the importance of race qualities. Those scientists who adhere to the opposing view maintain with equal positiveness that the supremacy of New England has long been exaggerated. There was no time, these men insist, at which New England had an immense lead in the production of greatness over the other sections of the country, if its percentage of population at that time was taken into consideration. Furthermore, so the argument continues, the supremacy of New England in the production of distinguished men is being rapidly taken over by the middle west. It is in that section that the leaders of the next generation are being born.

The contention is, in its nature, both interesting and endless, unless some facts can be obtained which will throw some light upon the questions at issue. These, I take it, are three:

1. Was there ever a time when the number of distinguished men born in New England was greater in proportion to its population than the proportion for other sections of the United States?
2. Has there been any change in the proportion of distinguished persons contributed by New England?
3. What contributions of distinguished persons are now being made by the various sections of the United States?

These questions can not be answered with certainty. The available facts make unimpeachable conclusions impossible. Nevertheless, approximations may be made which should throw some light on the questions.

The volume entitled "Who's Who in America" for 1912–13 contains

18,794 names.[1] This list purports to include the distinguished men from every walk of life in the United States. The compilation is necessarily incomplete. There are, of course, omissions; while the mere classification of a name in "Who's Who in America" is no guarantee of distinction. On the whole, however, it may justly be said that the proportion of distinguished men whose names are inserted in "Who's Who in America" is about the same for the various professions. Furthermore, there is no reason to suppose that the proportion secured from different sections of the country would show any material variation. All things considered, these 18,794 names seem to offer the most available basis for a study that would answer the questions regarding the supremacy of New England in its production of distinguished persons.

A study of the data in "Who's Who" was made in the following manner. A schedule was arranged to show, first, the profession; second, the decade of birth; and third, the place of birth of the consecutive names, beginning with the first page of the volume. In order to make the information as usable as possible, the returns for each state were separately tabulated, as were the returns for those cities which reported a population of more than 20,000 in 1850. These items of information were secured for the first 10,000 native-born persons. The generalization from the first 10,000 names can safely be applied to the remainder of the volume.

The first point of interest arises in connection with the number and per cent. of distinguished persons from each section of the United States and the per cent. of the total population of the United States in the respective sections. These figures (Table I.) show at a glance the proportion of distinguished persons born in the various localities.

These returns, on their face, accord to New England a lead in the total number of distinguished persons produced that is little short of phenomenal. With less than a fourteenth of the population, New England has been the birthplace of almost a quarter of the total number of distinguished persons whose names appear in "Who's Who." The Middle Atlantic States, with a fifth of the population, report somewhat less than a third of the distinguished men; the East North Central States report almost equal proportions of distinguished persons and of population; while the other sections show a proportion of population considerably above the proportion of distinguished persons born. There are

[1] "Who's Who" is published in Chicago. The editor, Albert Nelson Marquis, was born in Ohio. "The standards of admission to 'Who's Who in America' divide the eligibles into two classes: (1) Those who are selected on account of special prominence in creditable lines of effort, making them the subjects of extensive interest, inquiry or discussion in this country; and (2) those who are arbitrarily included on account of official position—civil, military, naval, religious or educational—or their connection with the most exclusive learned or other societies." From a statement following the preface, 1912–13 edition.

TABLE I

NUMBER AND PER CENT. OF EMINENT PERSONS BORN IN THE VARIOUS GEOGRAPHICAL DIVISIONS OF THE UNITED STATES WITH THE PER CENT. OF THE TOTAL POPULATION OF THE UNITED STATES IN EACH DIVISION IN 1910[2]

Geographical Division	Eminent Persons		Per Cent. of the Total Population of the United States, 1910
	Number	Per Cent.	
United States	10,000	100	100
New England	2,311	23	7.1
Middle Atlantic	2,974	30	21.0
East North Central	2,225	22	19.8
West North Central	542	5	12.7
South Atlantic	1,091	11	13.3
East South Central	546	6	9.1
West South Central	161	2	9.6
Mountain	28	—	2.9
Pacific	122	1	4.6

therefore three sections of the United States—New England, the Middle Atlantic States, and the East North Central States—in which a comparatively large number of distinguished persons were born. These three groups of states lie in a contiguous territory, in the northeastern section of the United States. Of the three groups, New England, in proportion to its population, has by far the largest proportion of distinguished persons.

The figures in Table I. are manifestly incomplete. Changes in population have been rapid during the past few decades. The tide of westward movement has materially altered the population center. No final conclusion regarding the position of New England as a contributor of distinguished persons can be reached unless the gross result is corroborated by the facts showing the time at which the distinguished persons were born, and the proportion of the population in the various sections of the country at that time.

TABLE II

NUMBER AND PER CENT. OF EMINENT PERSONS WHO WERE BORN AT CERTAIN TIMES

Time of Birth	Number	Per Cent.
Before 1850	2,818	28
1850–1859	2,715	27
1860–1869	2,717	27
1870–1879	1,304	13
1880–1889	95	1
1890–1899	2	—
Unknown	349	4
Total	10,000	100

[2] Of these 10,000 eminent persons, 779, or 7.8 per cent., were women. Sex will not be considered in the present article.

A surprisingly large number of the eminent persons whose names appear in "Who's Who in America" were born before 1850. Table II. gives the time of birth by decades.

The eminent persons who were alive in 1912–13 are, for the most part, well along in life. Only one in a hundred was born since 1880; only fourteen in a hundred were born since 1870. Men born before 1870 were at least forty-two years old in 1912. In so far as time records are concerned, this study must deal with the period prior to 1870, since the great body of eminent persons was born before that date. More than a quarter of the total eminent persons was born before 1850, making them at least sixty-two years old. More than four fifths of the entire number were born before 1870; that is, they are at least forty-four years of age. In so far as time is a factor, interest centers in the periods before 1850, 1850–1859, and 1860–69.

The total returns give New England a material lead in the production of eminent persons. Is that lead maintained when the totals are broken up into time periods? The relation between the decade of birth, the place of birth, and the proportion of population in each section at the time of birth appears in Table III. The proportion of eminent persons born before 1850 is compared with the population in 1850. The proportion born between 1850 and 1859 is compared with the population of 1860. The population figures, in each case, refer, not to the time of birth—such a comparison is manifestly impossible. The total born in each decade is compared with the population at the end of that decade. This method should militate slightly in favor of New England, whose population in each decade constitutes a slightly smaller proportion of the total population of the United States.

TABLE III

Geographical Division	Per Cent. Born Before 1850	Per Cent. of Pop. 1850	Per Cent. Born 1850–1859	Per Cent. Total Pop. 1860	Per Cent. Born 1860–1869	Per Cent. Total Pop. 1870	Per Cent. Born 1870–1879	Per Cent. Total Pop. 1880	Per Cent. Born 1880–1889	Per Cent. Total Pop. 1890
United States	100	100		100		100		100		100
New England	30	11.8	23	10.1	19	9.1	19	8.1	12	7.5
Middle Atlantic	33	25.4	32	23.8	26	22.9	25	20.9	37	20.2
East North Central	17	19.5	23	22.1	27	23.7	23	22.3	25	21.4
West North Central	2	3.8	4	6.9	8	10.0	10	12.2	6	14.2
South Atlantic	12	20.2	10	17.2	11	15.2	12	15.1	11	14.1
East South Central	5	14.5	5	12.3	5	11.4	5	11.1	4	10.2
West South Central	1	4.1	2	5.6	2	5.3	2	6.7	2	7.5
Mountain	—	.3	—	.6	—	.8	1	1.3	—	1.9
Pacific	—	.5	1	1.4	2	1.6	3	2.3	3	3.0
Total names	2,818		2,715		2,717		1,304		95	

A perusal of Table III. reveals several very evident situations. The first three groups of States—New England, the Middle Atlantic States

and the East North Central States—are plainly in a class by themselves. Among these states, in every instance except one (the East North Central States, 1850), the proportion of eminent persons born in those groups of states is higher than the proportion of the total population found in those states at the same time. Among the other groups of states, in every case except two (Pacific States, 1870 and 1880), the proportion of eminent persons born is lower than the proportion of the total population found in the states. It therefore appears that of the eminent persons born up to 1890, the vast proportion were in that northeastern section of the United States bounded by the Mason and Dixon line on the south, and the line of the Mississippi-Missouri River on the west.

Among these northeastern groups of states New England holds a unique position. Throughout the entire period she appears as the birthplace of a far larger proportion of eminent persons, in proportion to her population, than either of the other groups. During the early years her lead was little short of remarkable. Of the distinguished persons born before 1850, she produced almost one third, while her population in 1850 was but one ninth of the total population of the United States. The Middle Atlantic States, with a quarter of the population, produced only a little more than a quarter of the eminent persons. The same relation between the two sections holds true of the decade from 1850 to 1859. In this period New England has one tenth of the population, and one fourth of the distinguished persons, while the Middle Atlantic States have a quarter of the population, and about a third of the distinguished persons. Even as late as 1880 the ratio between the proportion of eminent men and of population is higher in New England than in any other section except the Middle Atlantic States. At the same time, the East North Central States, with the single exception of the years before 1850, report a proportion of distinguished persons born only a little higher than their proportion of the population. During the first three periods the relative proportions of eminent persons born and of population are fairly similar in the Middle Atlantic and the East North Central States, but at the same time very markedly below the standard set by New England.

The considerable lead of New England and the marked lead of the Middle Atlantic States and the East North Central States over the other sections of the country may be tested in various ways. Instead of comparing the proportion of eminent persons in the various sections with the total population, a comparison may be made with the native white population. This seems particularly fitting in view of the large negro population in the south, which has contributed so little to the number of eminent persons in the country. Such a comparison is likewise desirable in those states of the north where there is a large proportion of foreign-born persons. A comparison appears in Table IV., where the number of eminent persons per one hundred thousand of total population and of native white population is given.

TABLE IV

THE GEOGRAPHICAL AREAS IN WHICH UNUSUALLY HIGH PROPORTIONS OF DISTINGUISHED PERSONS WERE BORN

Geographical Area	Total Distinguished Persons	Distinguished Persons	
		Per 100,000 Total Population 1880	Per 100,000 Native White Population 1880
United States	10,000	19.9	27.1
New England	2,311	57.6	72.4
Middle Atlantic	2,974	28.4	35.9
East North Central	2,225	19.9	24.4
West North Central	542	8.6	10.9
South Atlantic	1,091	14.2	24.3
East South Central	546	9.8	15.3
West South Central	161	4.9	7.8
Mountain	28	4.3	6.0
Pacific	122	10.9	16.3
Vermont	219	65.9	75.5
Massachusetts	1,123	62.9	85.8
New Hampshire	189	54.5	63.1
Connecticut	334	53.6	69.2
Maine	319	49.2	54.3
Rhode Island	127	45.8	64.8
New York	1,778	34.9	46.6
Pennsylvania	941	21.9	26.1
Ohio	859	26.8	31.5
Delaware	41	27.8	37.0
Maryland	218	23.3	33.9
Virginia	266	17.5	30.7

The facts appearing in Table IV. do not in any material way change the apparent status of New England with respect to the other sections of the United States. As regards both the number of eminent persons per 100,000 of total population, and of native-born population, New England appears far in the lead among the other sections of the country. New England's lead is even more marked when the situation is studied in the individual states. The individual states appearing in Table IV. are those which showed a proportion of eminent persons higher than that for the United States at large. Without a single exception, these states are in the northeastern portion of the United States. The list contains every one of the New England States, a portion of the Middle Atlantic and the East North Central States, and no other state. Furthermore, each of the New England States, taken individually, shows a higher proportion of eminent persons than any other single state, or than any other group of states. The supremacy of New England lies, not in any one state, or in any one locality. Vermont leads the list; Rhode Island brings up the rear; yet the proportion of eminent persons born in Rhode Island per 100,000 of total, and of native-white population, is 30 per

cent. above New York, the state outside of New England coming next in rank.

There is another test to which the figures may be subjected. There may conceivably be some relation between the educational advantages offered in cities and the proportion of eminent men developed in any population. The champions of environment as the modifying factor in life insist that the influences of city life go far to outweigh heredity qualities. Therefore, since the northeastern portion of the United States was the original center of educational activity, and since it now contains the largest proportion of city population, it might well be expected to produce the largest proportion of eminent persons.

There were twenty-seven cities which reported a population of more than 20,000 in 1850. A separate tabulation for these gives an excellent idea of the proportion of eminent persons born in city and rural districts. In passing, it is interesting to note that of these twenty-seven cities,

4 were in New England,
10 were in the Middle Atlantic States,
4 were in the East North Central States.

The other six geographical divisions of states have but nine of the twenty-seven cities.

TABLE V

EMINENT PERSONS WHO WERE BORN IN THE CITIES OF THE UNITED STATES WHICH HAD A POPULATION OF 20,000 OR OVER IN 1850, WITH THE PER CENT. OF THE TOTAL POPULATION OF THE UNITED STATES LIVING IN THOSE CITIES IN 1850 AND IN 1880

Time of Birth	Total Eminent Persons	Eminent Persons Born in 27 Leading Cities	Per Cent.
Before 1850	2,818	599	21.2
1850–1859	2,715	610	22.5
1860–1869	2,717	591	21.7
1870–1879	1,304	363	27.8
1880–1889	95	38	40.0
No age	351	123	——
Totals	10,000	2,324	23.2

During the entire period under consideration, these twenty-seven cities contained from one twelfth to one eighth of the population of the United States. The proportion of the total population of the United States living in these twenty-seven cities was,

In 1850..... 8.7 per cent.
In 1860..... 11.2 per cent.
In 1870..... 12.8 per cent.
In 1880..... 13.1 per cent.

These percentages afford a striking contrast to those in Table V. The percentage of population living in these twenty-seven cities was never more than one seventh of the total population of the United States. During this time they reported never less than one fifth of the eminent persons born. Whatever the cause of this preponderance of eminent persons who come from a city environment, the facts are certainly remarkable. The cities appear to be far in the lead as producers of eminence.

There is no absolute correspondence between the proportion of urban population and the proportion of eminent persons born.[3] An analysis of the per cent. of population which is urban shows that while New England is far in the lead of the other sections of the country, there are a number of states which report a large proportion of eminent persons born and a comparatively small proportion of urban population. The reverse condition is also true. Rhode Island, with the lowest proportion of eminent persons reported by any New England State, has the highest percentage of urban population (93.5 per cent.) of any state in the union. New Hampshire, with the highest proportion of any New England state, has only 38.9 per cent. of the population urban. New Jersey, with a percentage of 53.7 urban, reports the lowest proportion of eminent persons of any state in the Middle Atlantic group.

Any tendency to attribute the supremacy of New England in the proportion of distinguished persons which it has contributed to the presence of large urban populations is offset by an examination of the figures for the cities themselves. The New England States are in the lead of the other states, but the New England cities are not in the lead of cities from other sections of the country. Indeed, an examination of Table VI., which contains a statement of the total eminent persons per 100,000 of the population in 1870 for the various cities, as well as the total born in each of the specified decades, shows very clearly that the cities in other sections of the country are decidedly in the lead. Boston and Providence alone, among the New England cities, have a proportion of eminent persons higher than that for the United States at large.

Whatever the cause of New England's position as the undisputed

[3] PER CENT. OF POPULATION (1880) WHICH IS URBAN IN THOSE SECTIONS AND STATES HAVING THE HIGHEST PERCENTAGE OF EMINENT PERSONS

Division	Per Cent. Urban Population
United States	29.5
New England	68.7
Middle Atlantic	49.9
East North Central	27.5
West North Central	18.1
South Atlantic	15.1
East South Central	8.4
West South Central	12.2
Mountain	23.6
Pacific	36.2

mother of American greatness, it apparently is not due to the presence of a large percentage of urban population. The facts showing urban and rural population point in no conclusive direction.

TABLE VI

RATIO BETWEEN THE NUMBER OF EMINENT PERSONS BORN IN CERTAIN CITIES AND THE POPULATION OF THOSE CITIES

Geographical Area	Decade 1850–1859	Decade 1860–1869.	Decade 1870–1879.
United States	8.9	7.0	2.6
New England	19.6	15.0	6.2
Middle Atlantic	11.4	8.1	3.1
East North Central	9.1	7.8	2.7
Boston	39.5	23.9	8.3
Cleveland	41.2	18.3	1.0
Providence	35.6	17.4	9.5
Washington	31.2	21.9	13.6
Syracuse	28.6	11.6	7.7
Milwaukee	24.4	14.1	3.6
Detroit	24.1	20.2	6.1
San Francisco	21.1	11.4	5.6
Chicago	18.3	14.4	6.3
Baltimore	12.4	14.2	6.0
Cincinnati	15.5	10.6	5.9
Philadelphia	14.5	10.8	5.6
St. Louis	14.3	6.4	3.7
Brooklyn	13.2	10.7	4.2
Richmond	13.2	9.8	4.7
Portland	11.4	25.8	8.7
Troy	17.9	10.9	7.1

To guard against the objection that the supremacy of New England was due to the inclusion of an undue number of preachers and school teachers in the "Who's Who" figures, an analysis was prepared of the statistics by professions. The 10,000 persons are divided rather evenly over the different professions, with the two exceptions of educators and lawyers. Table VII. contains the figures for the professions at large.

TABLE VII

NUMBER AND PER CENT. OF EMINENT PERSONS WHO WERE IN CERTAIN PROFESSIONS

Profession	Number	Per Cent. of Total
Educators	1,932	19.3
Lawyers	1,354	13.6
Business men	998	9.9
Public office holders (except Army and Navy).	916	9.2
Authors	908	9.1
Clergymen	732	7.3
Doctors	619	6.2
Scientists	614	6.1
Journalists	595	6.0
Army and Navy	430	4.3
Miscellaneous	902	9.0
Total	10,000	100.0

The returns do not show on their face any justification for the belief that the various professions have been so picked as to militate in favor of New England. Indeed, it is apparent that all of the leading professions are well represented. Therefore, if New England makes a fair showing in a goodly number of the professions, the conclusion may be justifiably drawn that New England stands out in specific instances, as well as in general, as the producer of eminent persons.

The figures in Table VIII. contain a statement of the proportion of persons in the different professions for each of the geographical divisions of the United States.

TABLE VIII

PER CENT. OF EMINENT PERSONS IN THE FIVE PROFESSIONS HAVING THE LARGEST NUMBER OF NAMES IN "WHO'S WHO," CLASSIFIED BY PLACE OF BIRTH, FOR THOSE SECTIONS HAVING THE HIGHEST NUMBER OF EMINENT PERSONS

Place of Birth	Educators	Lawyers	Business Men	Public Office Holders	Authors	All Professions
New England	24.2	17.1	26.8	16.9	26.5	23.1
Middle Atlantic	25.2	29.8	33.3	20.1	30.7	29.8
East North Central	25.7	22.0	21.6	23.8	21.5	22.2
West North Central	5.7	4.9	5.1	7.3	5.7	5.5
South Atlantic	12.7	13.2	7.9	15.4	6.5	10.9
East South Central	5.0	8.2	3.0	9.6	5.4	5.4
Other Sections	1.5	4.8	2.3	6.9	3.7	3.1
	100.0	100.0	100.0	100.0	100.0	100.0

The supremacy of the northeastern section of the United States is again amply demonstrated. Throughout the period under consideration, this section of the country has contained less than three fifths of the total population.[4] There is an almost equal percentage of educators in the three sections. The Middle Atlantic States lead notably in the percentage of lawyers and business men, while among public office holders, authors and all other eminent men, the three sections are on comparatively equal terms.

The time has now come when the three questions propounded at the outset of this paper may be answered with some color of authority. The answers are not final, but they are significant in so far as "Who's Who" is authoritative.

The answer to question one is clear and unequivocal. "Was there ever a time when the number of distinguished men born in New England was greater, in proportion to its population, than the production for the other sections of the United States?" In the past New England has

[4] In 1850 the New England States, the Middle Atlantic States and the East North Central States contained 56.7 per cent. of the population; 55.7 per cent. in 1860; 55.5 per cent. in 1870.

towered head and shoulders above the other sections of the United States in her production of eminent persons. Two other sections, the Middle Atlantic and the East North Central States, alone approach her record, and they lag far behind her pace.

The second question is not so susceptible of positive answer—"Has there been any change in the proportion of distinguished persons contributed by New England?" Such a change has undoubtedly taken place. Until 1880 New England took first rank. Up to that time her supremacy can not even be disputed. With that decade, New England drops behind the Middle Atlantic States. Whatever the cause of the change, the change is itself forcing the New Englander's lead very hard.

The third question: "What contribution of distinguished persons is now being made by the various sections of the United States?" may not be answered in any dogmatic way. New England is evidently contributing a less high proportion of distinguished persons. The Middle Atlantic States, the East North Central States, and the Pacific States are striding rapidly to the front. Thus far (the decade of 1880–1889) the Middle Atlantic States lead, with New England second, and the East North Central States third.

All the facts at hand point to New England as the one-time birthplace of the largest proportion of distinguished persons. The center is shifting, however, into New York, Pennsylvania and Ohio. That New England once held the palm is a statement that must go without challenge. That she can or will continue to hold it seems doubtful. Meanwhile, of the persons whose names found their way into "Who's Who in America" an overwhelming proportion seem to have been born in that section of the northeastern United States bounded by the Mason and Dixon line on the south, and the Mississippi-Missouri River on the west.

THE RÔLE OF SEX IN THE EVOLUTION OF MIND

By Professor S. J. HOLMES
THE UNIVERSITY OF CALIFORNIA

THE reason for the existence of sex is one of those biological problems which has long perplexed the scientific world, and to-day its solution seems as remote as it did a century ago. Many remarkable discoveries have been made in regard to the microscopic structure and development of the germ cells. We have learned much of the general biology of sex, and the probable evolution of sex in the organic world. And substantial progress has been made in respect to the old problem of the determination of sex. But to the question, Why came there to be two sexes at all? or, in other words, Why did not organisms continue to reproduce asexually as it is probable they once did? we can only offer answers that, at best, are very hypothetical. The bacteria and the blue-green algæ, so far as careful investigation has yet ascertained, reproduce exclusively by the asexual method, usually by fission or the formation of spores. But among the higher plants and in nearly all animals we find the existence of two sexes of very general occurrence. While the fact that sex is absent in the lowest forms of life indicates that evolu- has proceeded, at least a certain distance, without its aid, and suggests the possibility of the evolution of sexless forms of a high degree of organization, yet the general prevalence of sex in all but the most primitive organisms points to the conclusion that sex has played a fundamental rôle in the evolution of the organic world. There are many theories as to the part which sex has played, but the profound disagreement among several of these which have secured the widest following is significant of how little is positively established in regard to this subject.

While the cause of the development of sex may remain obscure, it is not difficult to point out some of its consequences, although it would be futile to attempt a very accurate picture of what the organic world would be had sex never been evolved. Even if the processes of variation and selection had gone on to the same extent—which is scarcely probable—the absence of sex would have given a very different direction to evolution from that which was actually followed. Many of the most complex structural arrangements of organisms have especial reference to the union of the germ cells. The color and scent of flowers, and their many and beautiful adaptations to secure cross fertilization would never have appeared if plants were propagated exclusively by the asexual method, and this would doubtless have entailed more or less extensive changes in other parts of the organism. In animals the structural peculiarities

associated with sex are as a rule among the most complex features of the body. Some animals, to be sure, simply discharge their sex cells into the water, leaving their union to chance, but in the majority of cases, especially in higher forms, there exist elaborate mechanisms to insure the meeting of these cells. Correlated with these structures we find mating instincts which frequently manifest themselves in complex modes of behavior. More acute senses have been evolved in many cases very largely for effecting the meeting of the sexes. The large antennæ of male moths, the large eyes of the common drone bee, and the auditory apparatus of the male mosquito are a few of the countless illustrations of this fact. The various apparatus in insects for making sounds which are found in crickets, locusts, cicadas, etc., are devices for securing the meeting of the sexes, and the complementary development of the auditory apparatus in the same insects has doubtless been furthered through the evolution of these structures.

Much of the elaborate organizations of the imago stage of insects has reference, directly or indirectly, to activities concerned in mating and depositing the eggs in the proper environment for the development of the young. There is a relatively long larval or nymphal period chiefly devoted to the vegetative functions of assimilating nutriment and growth; in many cases the imago takes no food, or need take none, before the eggs are fertilized and laid; and in several species the mouth parts have become so completely atrophied that food taking is impossible. Mating not infrequently occurs soon after the insects emerge from the pupal covering. In the may-flies, which live but a short time in the winged state, in order to mate and deposit their eggs it is probable that the imago stage would long ago have disappeared were it not retained as a means of effecting the union of the sexes. The same is doubtless true of many other insects. The activities of the imago state, broadly speaking, are primarily altruistic; they are concerned mainly with the welfare of other members of the species. They are also expensive. In the winged state numerous new enemies are encountered and many lives are lost. In the pupa stage which prepares for it there is commonly an extensive tearing down of old structures and the building up of new ones, during which the insect is helpless against many enemies.

Mating activities are almost everywhere among the most complex performances of an animal's life. The opposite sex must be distinguished from all other creatures and responded to accordingly. Often pursuit and capture or winning over are the necessary preliminaries to sexual union. All this puts a premium, so to speak, on the sharpening of the senses, the development of strength and activity, and the evolution of the higher psychical qualities. Consider the mating activities of crustaceans, the courtship of spiders, the breeding habits of fishes, and still more the elaborate wooing of male birds, and it will become manifest how

greatly the institution of sex has stimulated the evolution of complex modes of behavior.

All the facts here cited are trite enough, even to the non-biological reader. But while it is sufficiently evident that the differentiation of the sexes has promoted the development of behavior in relation to mating, it may be well to point out the enormous indirect consequences of this development in respect to the evolution of mind in general. In the evolution of behavior one kind of instinct grows out of another just as new organs are usually formed through the elaboration of some pre-existing structure. A general elaboration of instinctive reactions in regard to any one sphere of activity affords, therefore, a basis for the differentiation of more complex and specialized behavior in respect to other activities. To take a concrete illustration: The primary function of the voice in the vertebrates was to serve as a sex call, as is now its exclusive function among the Amphibia. Later and secondarily it came to be employed in relation to the protection of the young (through various instinctive calls) and as a means of communication with other members of the species. Finally in man it afforded the means of articulate language. It is not improbable, therefore, that the evolution of the voice, with all its tremendous consequences with respect to the evolution of mind, is an outgrowth of the differentiation of sex. Were it not for its value in effecting the mating of the lower vertebrates the voice might never have been evolved and man never have become man.

While the specialization of senses which in certain cases at least has been carried on mainly for sexual purposes has doubtless afforded the basis for the elaboration of many instincts, it is practically impossible to trace in detail how various instincts, sexual and other, have acted and reacted on one another's development. But we can discern enough of the influence of sex differentiation on the evolution of behavior to feel assured of its importance. The necessity for solving the one problem that confronts all dicœcious animals which do not simply shed their sexual products at random into the water, has tended to keep behavior in one sphere up to a certain minimum standard. The male must find and impregnate the female, and this fact sets a certain limit to his degeneration, at least in some period of his life, because any further degeneration would involve fundamental changes in the method of reproduction which may not be possible. But besides acting as a check to degeneration, the necessity for mating has in general been a constant force making for the evolution of activity, enterprise, acuity of sense, prowess in battle, and the higher psychic powers. One can not pretend, except in the most general terms, to gauge its rôle in the evolution of mind, but it has evidently been a factor of enormous potency.

THE PROGRESS OF SCIENCE

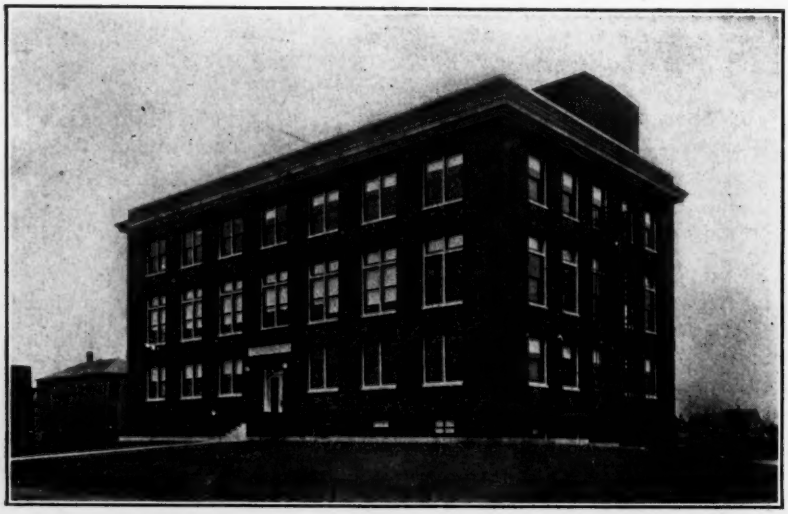
THE MARINE BIOLOGICAL LABORATORY

LOUIS AGASSIZ established in 1873 a marine biological laboratory on the Island of Penikese in Buzzard's Bay, south of Wood's Hole. Following his death the school was abandoned, but the plan was renewed in 1880 by the establishment of a seaside laboratory at Annisquam, in which Alpheus Hyatt was especially active. In 1888, the laboratory was reorganized and placed at Wood's Hole, where Spencer Baird had in 1881 established the marine laboratory of the U. S. Fish Commission. The natural advantages of fauna, climate and accessibility make Wood's Hole an ideal situation, and under the direction of C. O. Whitman a group of investigators gathered there in the summer who made the laboratory the chief center of biological research in this country and elsewhere only rivaled by Naples. After the death of Whitman, Professor Frank R. Lillie, of the University of Chicago, was made director, and later Professor Gilman A. Drew became assistant director, residing permanently at Wood's Hole. The laboratory has continued to grow in size and influence until last year there were 122 investigators and 69 students at work. If they were paid for their investigations at the rate other research institutions pay the cost would be more than half a million dollars a year.

As a matter of fact the laboratory has been conducted practically without endowment and with the simplest buildings and equipment. Some thirty universities and other institutions have cooperated in a modest way, but the work of the laboratory has been essentially a contribution of the biologists working there. There was urgent need of a fire-proof building that could remain open in the winter, and this has now been provided by Mr. Charles R. Crane, of Chicago, who in recent years has been the generous and sympathetic patron of the laboratory.

The building, an illustration of which is here shown, was planned by Mr. Charles Coolidge, of Boston, his designs being a gift to the laboratory, of which he has long been a trustee. The detailed arrangements are the result of much study with the help of many biologists and other laboratory men, and they have been admirably carried out by the assistant director, Dr. Drew. The building—50 × 90 feet—is constructed of tapestry brick with wide joints resting on a granite foundation, and trimmed with gray stone. It faces south on the Wood's Hole Harbor, about 150 feet away. The basement contains the chemical-supply room, janitor's quarters, heating plant, packing room and toilets. The first floor is divided into research rooms for zoology and physiology. A library with shelving for 20,000 volumes occupies the south half of the second floor with accession and storage rooms. The remainder of the floor and the third floor are occupied by research rooms. The roof carries a tank house with two tanks for salt water of 10,000 gallons each. The entire interior construction is of steel and reinforced concrete, with partitions of tile and granolithic floors, completely fire-proof.

The salt-water circulation is driven by electric automatically controlled motors, which open into two hard rubber pumps with a daily capacity of 75,000 gallons each. A gasolene engine is held in reserve in case of breakdown of the electric power service. The pipes and valves are all of lead, so that metallic contamination of the water can not possibly occur; the harbor water is



NEW BUILDING OF THE MARINE BIOLOGICAL LABORATORY.

of exceptional purity, owing to the strong tidal currents.

Each research room has a cement floor tank 5 × 3 feet, with a cement water table above, heavy birch tables surrounding the outside walls on which they are carried on iron brackets; gas and electricity for lighting or power, automatic telephone service to all other rooms in the building and to other buildings, steel shelving, fresh-water sink, etc.

The dedication exercises took place on July 10, and occupied the entire day. In the morning all the buildings were open for inspection and parties of visitors were conducted through by guides. The laboratory steamer took out a dredging party. Lunch was served to about 600 guests in the laboratory mess. The afternoon exercises were held in a large tent, with music by the Russian Balalaika Orchestra from New York. Mr. Crane presided and three short addresses were made by Professor Lillie, Professor Conklin and Dr. Hugh M. Smith, the U. S. Fish Commissioner, followed by an address on "The Needs of Research," by Dr. R. S. Woodward, president of the Carnegie Institution.

THE ST. PAUL MEETING OF THE NATIONAL EDUCATIONAL ASSOCIATION

So far as can be gathered from the meager despatches from St. Paul, the recent meeting of the National Educational Association was successful in attendance and in programs and maintained the progressive policies which have gained ascendancy in recent years. It will be remembered that the so-called "old guard" was definitely defeated in Boston, when the official nomination to the presidency of Mr. Z. X. Snyder, president of the Colorado Normal School, was superseded by the election of Mrs. Ella Flagg Young, superintendent of the Chicago Schools. *The New York Evening Post* says editorially that it is "astounding" and "wholly unexpected" that the association should vote in favor of the right of suffrage for women, but a similar resolution was passed unanimously at Chicago two years ago.

Among other principles and policies —commonplaces or radical innovations in accordance with one's point of view —which the association has favored are increased powers for the National Bureau of Education and the establish-

ONE OF THE OLD BUILDINGS OF THE MARINE BIOLOGICAL LABORATORY.

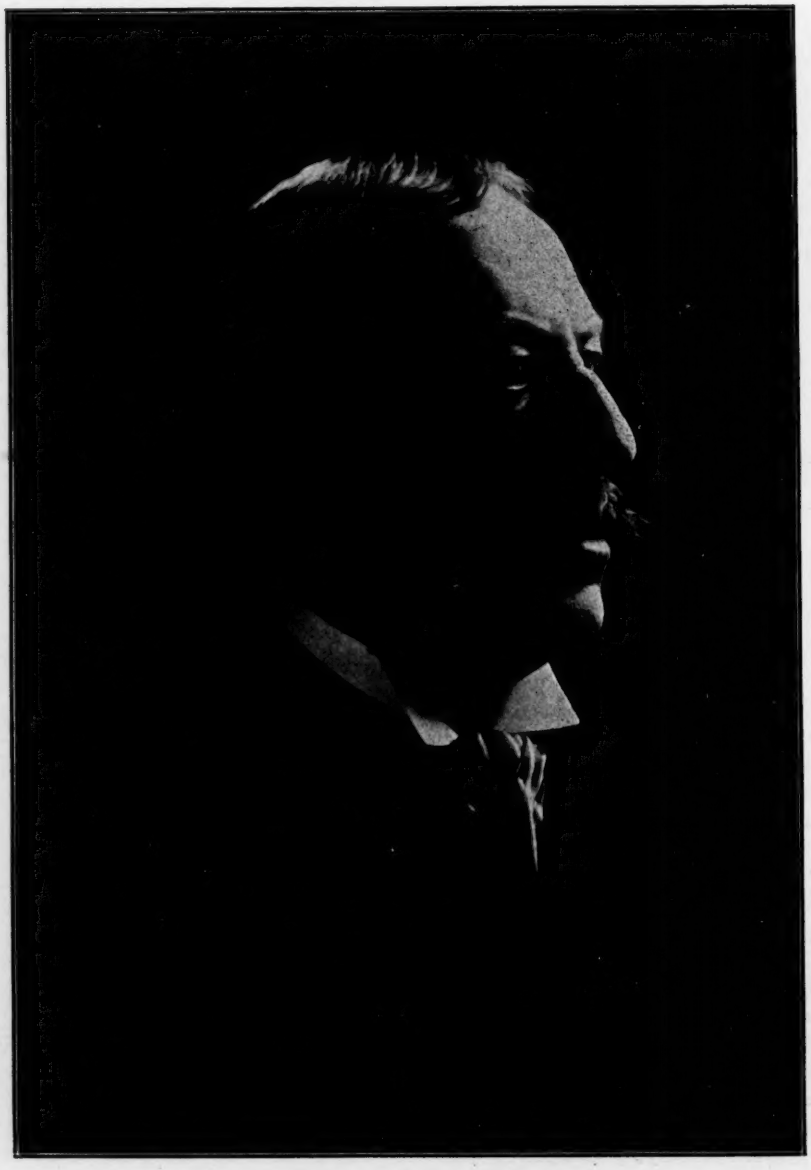
ment of a national university; increased national support of instruction in agriculture and domestic economy, such as congress has provided in this session; federal legislation in regard to child labor, marriage and divorce; for instruction favoring international good will and against military training in the schools; the use of the public school houses and grounds as social and recreation centers for the community; school district parks with instruction in gardening; vocational training and vocational guidance; instruction in sex hygiene in normal schools, but not in public schools, and the acceptance by the college of the education supplied by the high school. The association is naturally in favor of increased salaries for teachers and it endorses equal pay for equal work by men and women.

This year a resolution was passed condemning the activities of the General Education Board and the Carnegie Foundation for the Advancement of Teaching. Like the recent action of congress in forbidding cooperation between the Department of Agriculture and the General Education Board and in refusing a charter to Mr. Rockefeller's new foundation, this may in part be due to antagonism to men whose names have been associated with business methods and results which are no longer approved. But there is a wide-spread aversion to the meddling of these corporations with public education, or even to their dictating policies to other endowed institutions.

There was elected as president of the association for the next year, Dr. David Starr Jordan, from its establishment president and now chancellor of Stanford University, distinguished equally for his work in science, in education and for social progress.

MAJOR LEONARD DARWIN'S ADDRESS BEFORE THE EUGENICS EDUCATION SOCIETY

IN his address as president of the British Eugenics Education Society given at the annual meeting held in London on July 2, Major Darwin said that as citizens they must aid in the



DR. DAVID STARR JORDAN,
Chancellor of Leland Stanford Junior University, President of the National Education Association.

cure of the sick and in the alleviation of the destitute even though they saw that the multiplication of the less desirable types of humanity might thus be encouraged. One consideration, however, made them hope that eugenic advantages would not infrequently spring from reforms intended to affect human surroundings. The philanthropist's efforts resulted in the more easily cured or reformed being separated out from those less amenable to environmental influences. As social reform proceeded, and as the unfit were thus more and more clearly marked out from the nation at large, the numbers to be considered with reference to eugenic reform would be proportionately diminished, and racial progress would thus be facilitated. Social reforms producing these eugenic by-products must be utilized, as for example the proposed changes in the treatment of the habitual criminal. Improvement in environment would, no doubt, cause a diminution in crime, but a remnant of habitual criminals would remain, whose strong natural tendencies, being subject to the laws of natural inheritance, would infallibly tend to reappear in their descendants. To lessen their fertility seemed, therefore, within the scope of eugenic reform. Crime had a marked tendency to run in families.

Individuals endowed with those natural qualities, mental or physical, which render resistance to crime more than ordinarily difficult, are often brought into bad surroundings, mental or physical; this bad environment reacted on them, dragging them down in body and mind, and this action and reaction continuing either in the individual or generation after generation, the final resultant of these forces often was a long series of short imprisonments. The aim of the social reformer was, when possible, to break the vicious circle by at once removing the link of bad environment; whilst the eugenist would at the same time also strive to strengthen the innate characters of the individuals composing the coming generations. This latter result might be obtained by selective breeding.

A study of criminal family statistics surely must make the believer in environmental effects demand the segregation of the criminal-parent, both to safeguard the lives of those children who have been born into foul surroundings and to lessen the numbers of those children who would be born to face the perils thus arising. In short that seemed to be the right policy to adopt from whatever direction they approached this subject.

Much would have to be done before the machinery established under the mental deficiency act would produce the best possible results, and unquestionably this was the field to which the eugenist could now most usefully turn his attention. They could not form any trustworthy estimate of the number of criminals who would be dealt with under the provisions of the act, and they would sooner or later be driven to enquire whether some steps ought not to be taken with regard to the remainder of their habitual criminal population. If he could only be proved to be either very stupid, very weak or utterly worthless, was the man who committed crime after crime to be allowed to go on breeding freely? Few who had studied these questions with care had any doubt that habitual criminals ought to be detained for longer periods than at present, whilst every effort should be made to make that detention more curative in its effects.

The foregoing considerations had led many criminologists to advocate the system of "indeterminate sentences" in the case of habitual criminals. A reform much more easily obtainable, and one which the eugenist ought to endeavor to promote, would be the amendment of the prevention of crimes act in such a manner as to make it more readily applicable to the man of many minor offences. This act could easily be amended so as to make it easier to increase the periods of detention of those

thousands of unfortunate persons who possessed defects of character which drove them whenever free to a life of crime and made them an intolerable nuisance to society—defects which would inevitably reappear to some extent in their descendants if they had any. If they could get the paramount racial duty which they owed to posterity incorporated as an essential part of the moral code of the nation, then they would be on the high road to success.

SCIENTIFIC ITEMS

WE record with regret the death of Dr. Frederick W. True, assistant director of the Smithsonian Institution, known for his contributions to zoology, especially of the Cetacea; of Professor Seth Eugene Meek, assistant curator of zoology at the Field Museum of Natural History, Chicago, who was an authority on fishes and reptiles; of Dr. Rupert Norton, assistant superintendent of the Johns Hopkins Hospital; of Dr. Joseph Reynolds Green, F.R.S., known for his researches in plant physiology, and of Professor Hugo Kronecker, of Berlin, distinguished for his contributions to physiology.

AT the recent meeting of the American Medical Association, its gold medal was conferred on Surgeon General William Crawford Gorgas, who has also received honorary doctorates of laws from Princeton and Yale Universities.—The degree of LL.D. was bestowed by the University of California on commencement day on Eugene Woldemar Hilgard, from 1874 to 1906 professor of agriculture and dean of the College of Agriculture; on George Holmes Howison, Mills professor of intellectual and moral polity from 1884 to 1909.

MRS. MORRIS K. JESUP, who died on June 17, bequeathed $5,000,000 to the American Museum of Natural History and made other bequests to public institutions amounting to $3,450,000.